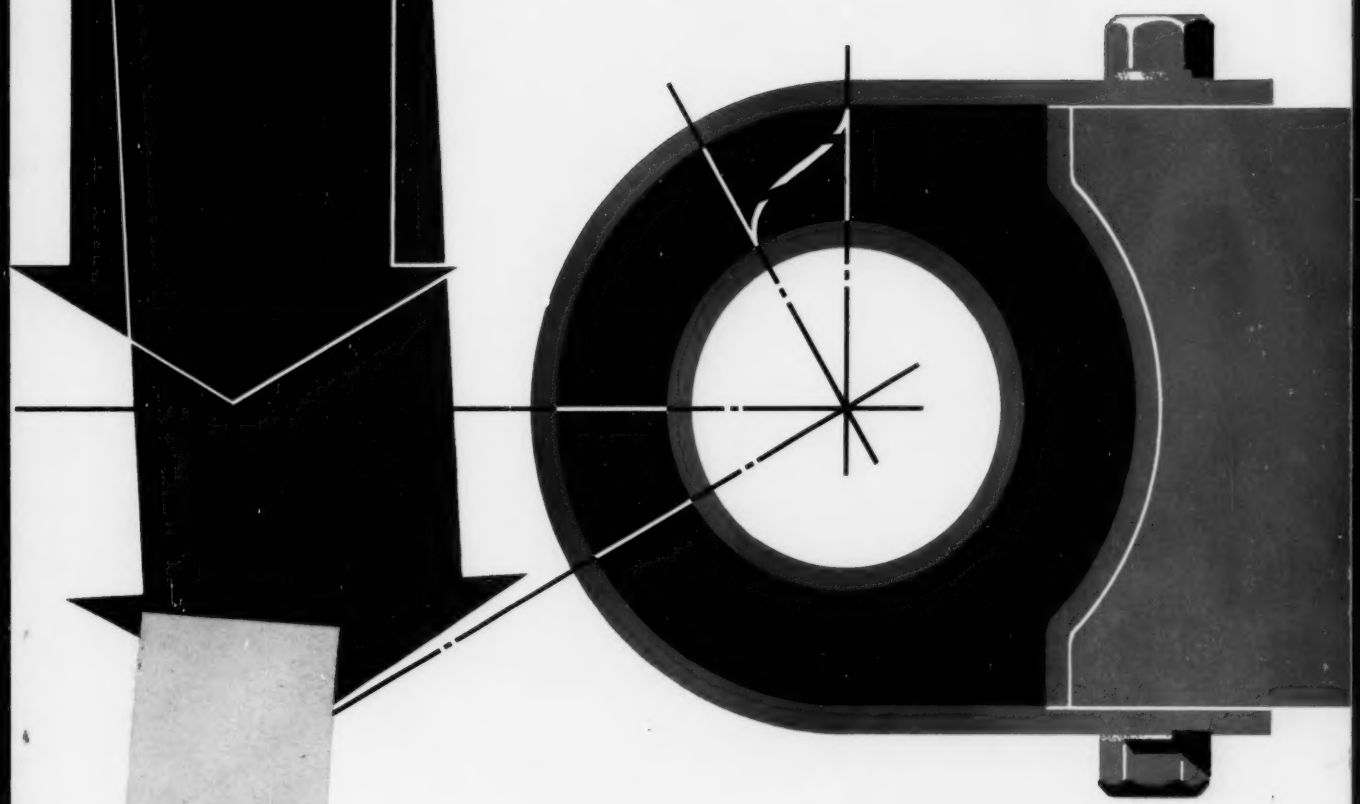
FEBRUARY 16, 1961

MACHINE DESIGN

A PENTON PUBLICATION — BIWEEKLY



Elastomeric Torsion Springs

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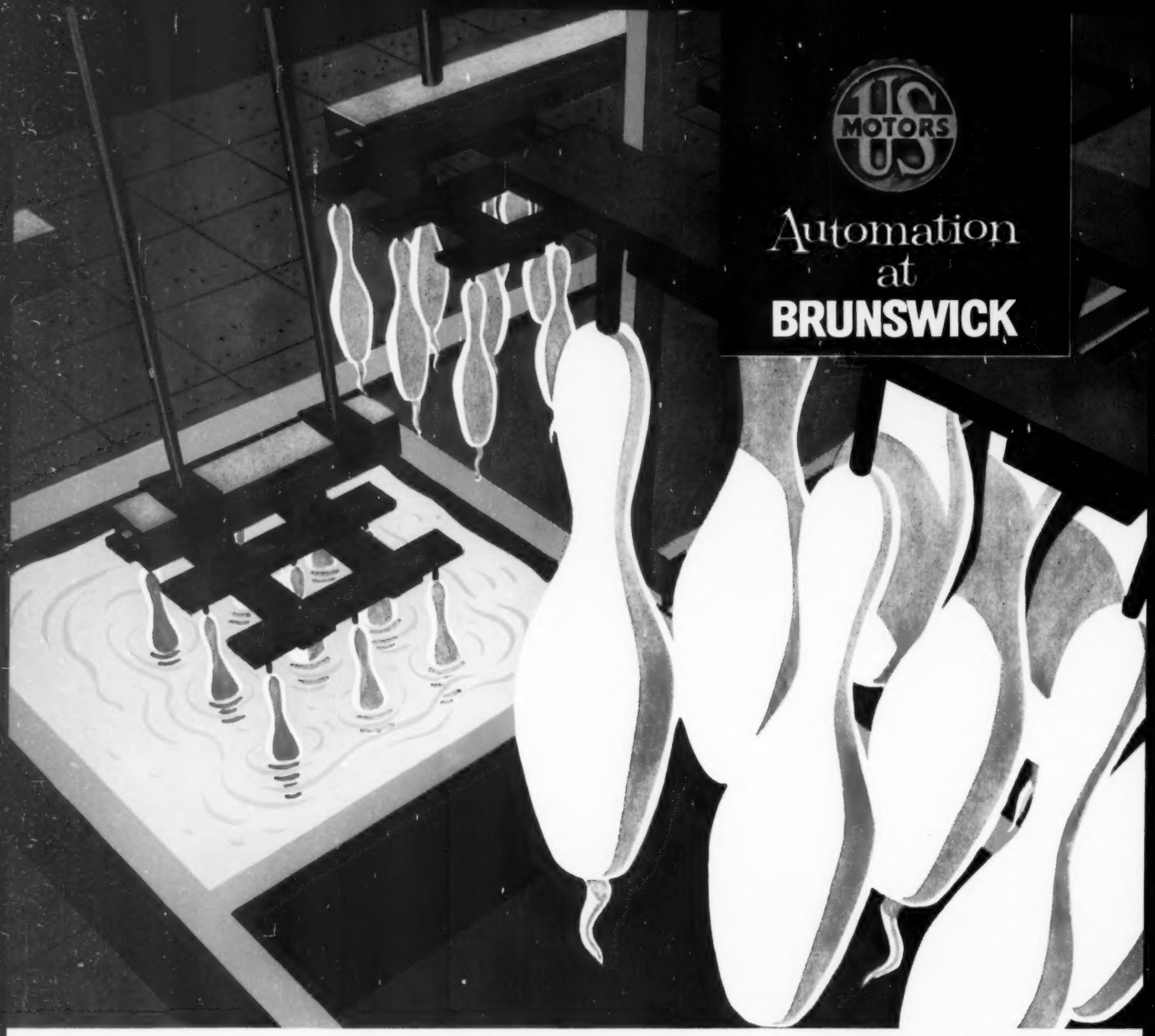
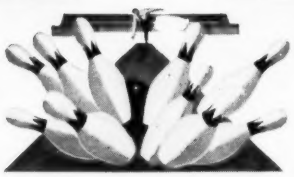


U.S. VARIDYNE system synchronizes conveyors for point-to-point pin transfer



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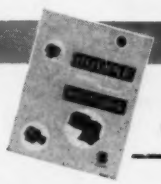

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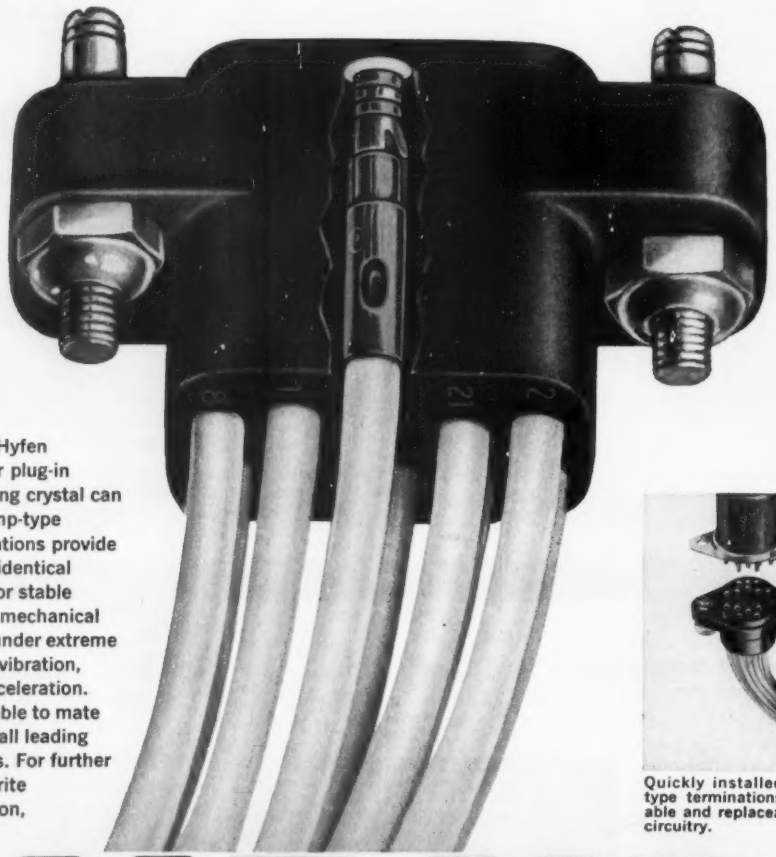

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THE PROFESSIONAL JOURNAL FOR ENGINEERS & DESIGNERS

MACHINE DESIGN

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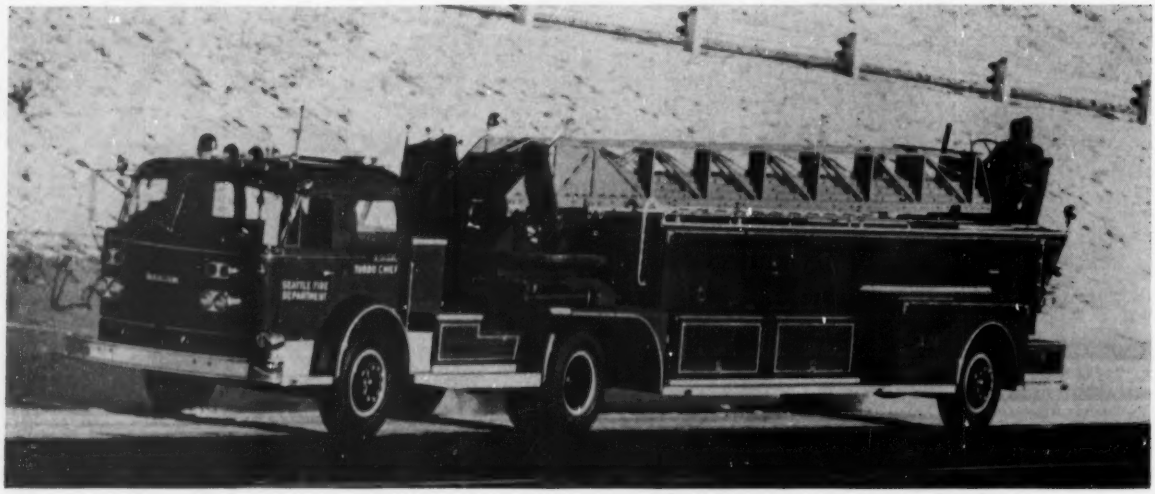


Powered by a pint-sized gas turbine, this 100-ft aerial ladder truck will outperform most fire fighters in its class. Engine is mounted right behind the cab.

Fire Trucks Are First with Turbines

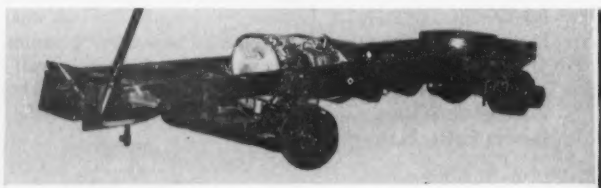
THE gas-turbine engine has finally arrived as an automotive powerplant . . . making its debut in one of the most colorful vehicles on the road—the big-city fire truck. Two of the nation's fire departments are now proud owners of turbine-powered fire-fighting equipment. San Francisco owns a 26,000 lb pumper; Seattle has a 32,000-lb, 100-ft aerial-ladder truck.

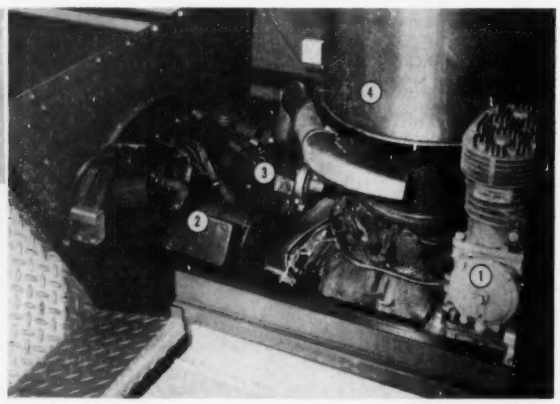
Both vehicles were designed and built by American LaFrance, a division of Sterling Precision Corp., Elmira, N. Y. Both are powered by Boeing 330-hp gas turbines. The free-turbine engines weight 325 lb, or about 1/10 the weight of conventional fire truck powerplants.

According to American LaFrance officials, the Seattle Turbo Chief is the fastest starting, fastest climbing fire truck in use. It achieved these speeds in tests:

- From a standing start—0 to 50 mph in 31 seconds.
- From a cold start—0 to 50 mph in 48 seconds.
- From a standing start—0 to 50 mph in 56 seconds on a mile-long hill with an 8 per cent grade.

Although the Turbo Chief is equipped with a standard five-speed truck transmission, it does most of its traveling in high gear because of the turbine's torque characteristics: 1200 lb-ft at stall; 840 lb-ft at 1600 rpm; 550 lb-ft at 3200 rpm (maximum output speed). This performance will be put to good use in both Seattle and San Francisco; the cities are known for hills.





All within easy reach, engine accessories (right) can be serviced quickly: 1. air compressor 2. starting motor 3. fuel pump 4. exhaust stack. Air compressor (12 cu ft) is for brakes, which are fitted with over-sized 10-in.-wide shoes. Starting motor revs turbine compressor up to 3000 rpm prior to ignition of fuel by glow plug. A 100-amp alternator, not shown, meets heavy fire truck electrical demands (lights, transmitter, hose reels). Compactness of engine is emphasized, above.

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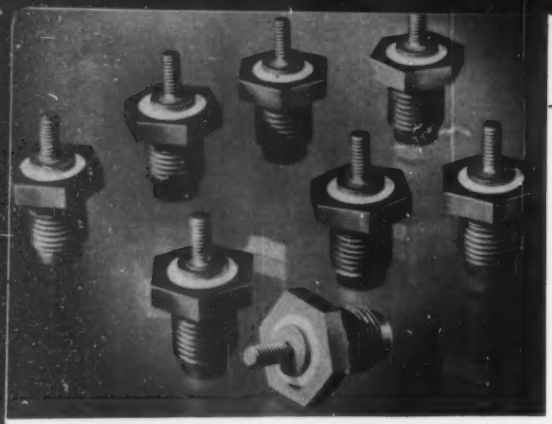
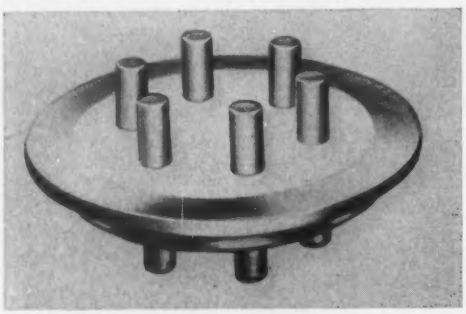


Hermetically-sealed parts now precision molded with Supramica 620 BB ceramoplastic are chip-detector plugs (above) and six-terminal heads (below). The new insulation will operate at temperatures up to 1200 F, widening the range of problems ceramoplastics can now solve. Heat generated by even the most densely packaged electrical and electronic equipment has no effect on components made from this material. In addition, it can be molded to complex geometries with extremely close tolerances.



From a temperature-resisting, precision-molding ceramoplastic:

Near-Perfect Seals For Electronic Parts

CLIFTON, N. J.—Ability to endure temperatures as high as 1200 F is only one of the advantages claimed for Supramica 620 BB, the newest ceramoplastic developed by Mycalex Corp. of America. The insulation material can be accurately molded to intricate shapes, and it forms a hermetic seal so tight that testing equipment can detect no leakage.

According to MCA president Jerome Taishoff, the material expands and contracts under temperature changes at the same rate as many metals. Since it can be precision molded with metal inserts, the seal formed is about as close to perfect as has ever been attained. Tests on precision-molded components made with a helium mass-spectrometer leak detector failed to turn up any hint of leakage, even though the spectrometer was sensitive enough to detect flows as small as 2×10^{-10} cu cm per sec—about 0.6 cu cm of helium in 100 years. The generally accepted standard "no leak" is 1×10^{-8} cu cm per sec.

Impervious to humidity, oil, water, and organic solvents, Supramica 620 BB is also resistant to nuclear radiation. Its high dielectric strength (270 v per mil) and excellent arc resistance (300 sec) are expected to improve reliability of connectors, coaxial seals, transducers, and other components.

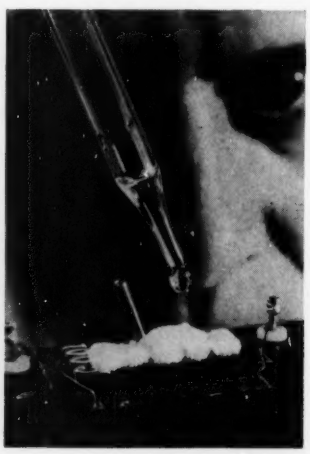
Thermoelectricity: Two More Off the Shelf

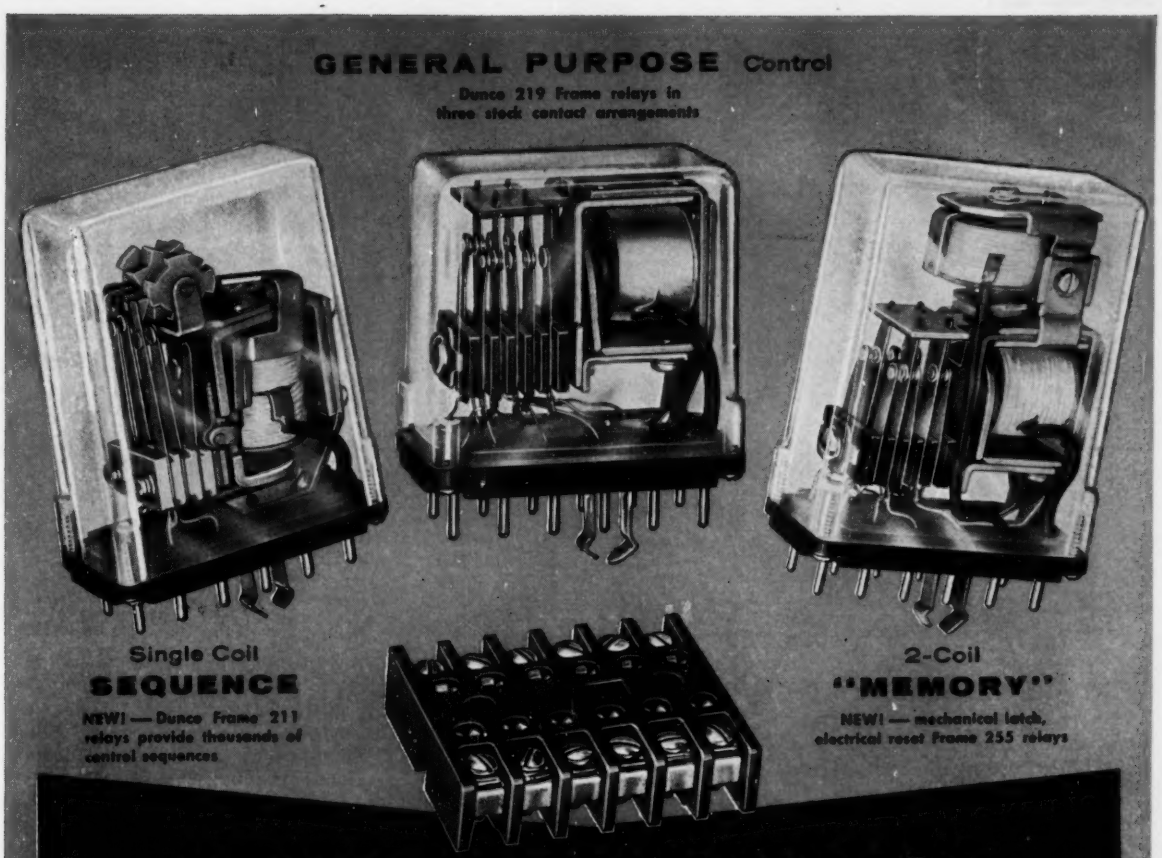
PRACTICAL THERMOELECTRIC hardware is reported by two front runners in the field: Hughes Aircraft Co. has designed a combination heater-cooler, and Westinghouse Electric Corp. has delivered a thermoelectric-nuclear generator for testing by the Air Force.

The Hughes device changes mode of operation at the flick of a switch. Operating on power provided by two flashlight batteries, it's eight times more efficient than conventional resistance heaters, yet (because of a newly developed method of fabricating thermoelectric materials) the cooler operates at one tenth the current previously needed. Hughes engineers have already constructed a three-stage, 2-amp model for an experimental infrared detector. It brings temperatures down to −100 F.

The Westinghouse generator is a completely portable nuclear device designed to furnish auxiliary power. Weighing less than 40 lb, the small, extremely reliable powerplant has a long life. When used with radioactive isotopes as the heat source, the generator produces about 150 watts of electrical energy. It has the highest efficiency of any direct-conversion equipment in its weight class and produces the most power per pound of generator weight.

Hughes heater-cooler (right) boils or freezes water equally well. Developed for space, the device will find earth uses too. Westinghouse generator (below) runs continuously for one year on a single fuel charge, will furnish power for remote unmanned installations.

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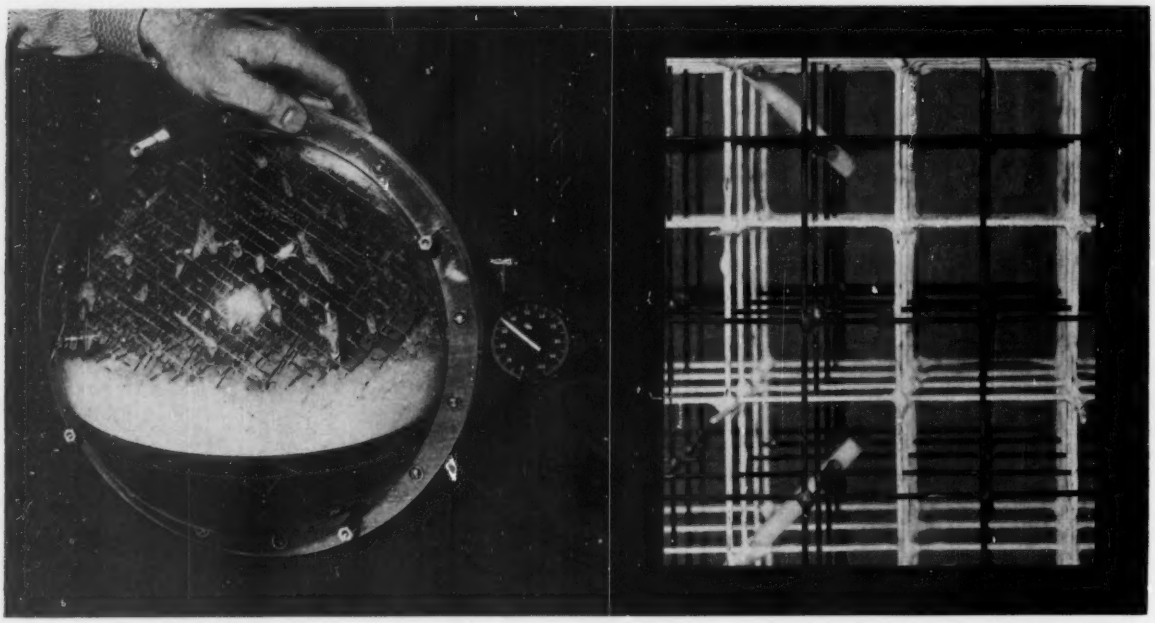


Built into a tank, or added as a "chain structure" through access doors, the high-capacity matrix-type gaging system measures liquid quantities with accuracy independent of tank configuration or orientation.

Wire Matrix Gages Zero-g Liquids

LONG ISLAND CITY, N. Y.—Gaging liquid quantities in the zero-gravity environment of a space vehicle obviously poses a unique problem—one not solved by conventional float or probe sensors. Tests carried out in aircraft flying "up and over" in zero-g (Keplerian) trajectories show that a weightless liquid balls up in a shapeless mass in the center of its tank, or foams into bubbles. Liquidometer Corp., an old hand at building all-attitude gaging systems for aircraft, suggests that such floating liquids can be measured by entrapping them in interlocking wire mazes.

Heart of the proposed system is a cubical matrix of wires (or small-diameter tubes) subdividing the entire volume of the tank. Another similar, but electrically independent, structure is constructed inside the first. Forming two active terminals of a three-terminal capacitor, the interlocking networks are insulated from the tank by Teflon spacers. Third terminal is the tank shell.

Whenever an incremental volume, or capacitor cube, is filled with liquid, the change in capacitance of the matrix is measured—and interpreted as liquid quantity—by a bridge circuit and servo system. According to Liquidometer, a high order of accuracy can be obtained without resorting to extremely small cube sizes—principally because capacitance varies in a nonlinear manner (rather than step-by-step) as cubes are emptied.

Besides an inherent insensitivity to tank attitude (1.4 per cent error for a 55-degree tilt), the matrix gage measures the average mass of liquid in foam with reasonable precision. Violently agitating a kerosene-filled tank (picture, above) Liquidometer obtained readings correct within 0.4 per cent of full scale.

Five-Year Plan: Dim Possibility for U. S. Engineers

DETROIT—The five-year engineering program *vs.* the four-year program has been debated for 25 years; to date, only three major institutions are operating on a five-year basis. So states J. Stuart Johnson, Dean of the College of Engineering of Wayne State University, discussing the pros and cons of this subject in the *Detroit Engineer*.

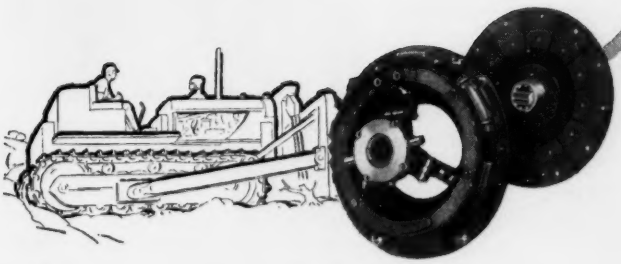
Dr. Johnson says, "Proponents of the five-year program point out the tremendous increase in technical knowledge, both basic and applied, even within the past decade. They show with real justification the need for more time in which to lay the educational foundations for the practice of engineering and for the continuing self-education which is a necessary part of this practice."

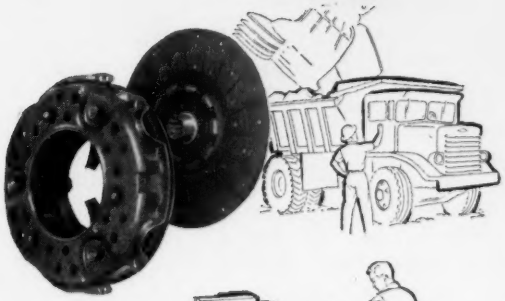
A modified five-year plan which seems likely to "advance the status of the profession" is a four-year pre-engineering baccalaureate program with the fifth year directed toward a specialty, but not equivalent to a master's degree.

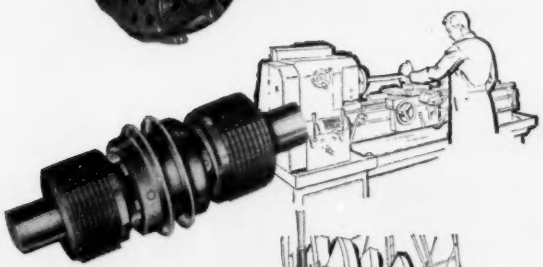
Those opposing a five-year program argue that "many qualified students would not be willing to embark on a five-year educational program when other attractive vocational areas are available not requiring this extra expenditure of time and money." Not only individual students, but many institutions as well, could not afford it.

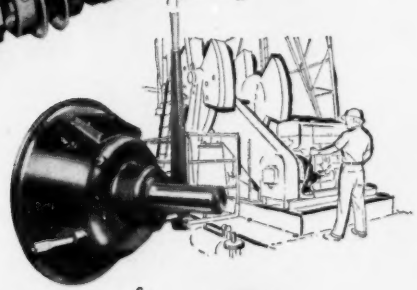
Although he feels that a student should not have to study five years before he receives a degree, Dr. Johnson thinks it likely that "some form of extended professional program prior to a graduate-school program is inevitable."

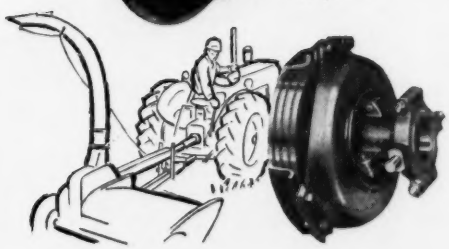
DYNAMIC POWER CONTROL
by ROCKFORD CLUTCH











EXTRA THICK FACINGS GIVE LONGER LIFE

Rockford Clutches have maximum thickness facings . . . up to 1/32" more friction material. Only the highest grade materials are used. Rockford's extra long-life facings reduce scoring and greatly cut costs of downtime, replacement and labor.

TORTURE PIT TESTING ASSURES SAFE OPERATION

Torture testing pits burst clutches to bits! At specified intervals, clutches are removed from the production line to undergo severe centrifugal tests. These clutches are spun to destruction but must withstand predetermined high speeds and specified time limits.

STRONG CONSTRUCTION WITHSTANDS RUGGED SERVICE

Corrosion resistant discs are made of high carbon spring steel. Heat treated cast iron improves grain structure of pressure plates. Strong construction is Rockford's key to long and rugged service.

VIBRATION-FREE CLUTCHES OFFER SMOOTHER ENGAGEMENTS

Smooth engaging Rockford Clutches are vibration-free! Rockford Clutch eliminates vibration through dynamic and static balancing. Clutch vibration can ruin bearings and crack housings. Minimum inertias prevent gear clashing and delayed shifting.

PRECISE PRODUCTION MEANS PRECISE PERFORMANCE

Each Rockford Clutch component is precision built. Rotary surface grinding assures uniform thickness. Discs are checked carefully for dish and run-out. Inspectors check close tolerances for flatness by pressure and weight-drop drag machines.

If you need clutches for original equipment or for replacement, Rockford Clutch offers the highest quality in power control. From research to inspection, Rockford Clutches are designed and built for long, rugged and reliable service. Rockford offers an ultra-wide range of power controls for all industries. Write today for illustrated brochure.

ROCKFORD CLUTCH

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Export Sales Borg-Warner International • 36 So. Wabash, Chicago, Ill.

ROCKFORD B-W CLUTCH DIVISION OF BORG-WARNER

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Cryogenic Magnets May Foster New Fusion Experiments

MURRAY HILL, N. J.—Scientists at Bell Telephone Laboratories have discovered a way to create extremely strong magnetic fields using a very small amount of electrical power. The development—involving cryogenics—is significant to the Bell System in its possibilities for improving the operation of certain tubes and devices used in ultra-high frequency radio-relay systems. It may also make practical many brand-new devices requiring high magnetic fields.

The discovery may also point the way toward a practical method of harnessing nuclear fusion, since it shows how the necessary strong magnetic fields might be created without vast amounts of electrical power. Current flow through Bell's superconducting magnetic coils will be started with small amounts of electrical power, and once the coil is energized, current will continue to flow without any power at all.

In the field of thermonuclear physics, large electromagnets have been used previously by scientists in their attempts to control fusion. The idea has been to contain high-speed atomic particles in a magnetic "bottle."

Some authorities have estimated that the input power needed to create a successful magnetic bottle with conventional electromagnets probably would exceed the power output of the fusion they seek to obtain, unless the machines were enormous. One proposal suggests the building of strong electromagnets fed with billions of watts of power supplied by special power plants—each large enough to serve a city of millions. In contrast, power equipment for the new superconducting solenoid will be small—perhaps a few hundred pounds.

The Bell electromagnet is the result of basic research in physics and metallurgy. The material used is an intermetallic combination of three parts of niobium (columbium) and one part tin. This material and its unusual superconducting properties were first predicted, discovered and published in 1954 by Bell scientists B. T. Mattias, T. H. Geballe, S. Geller and E. Corenzwit.

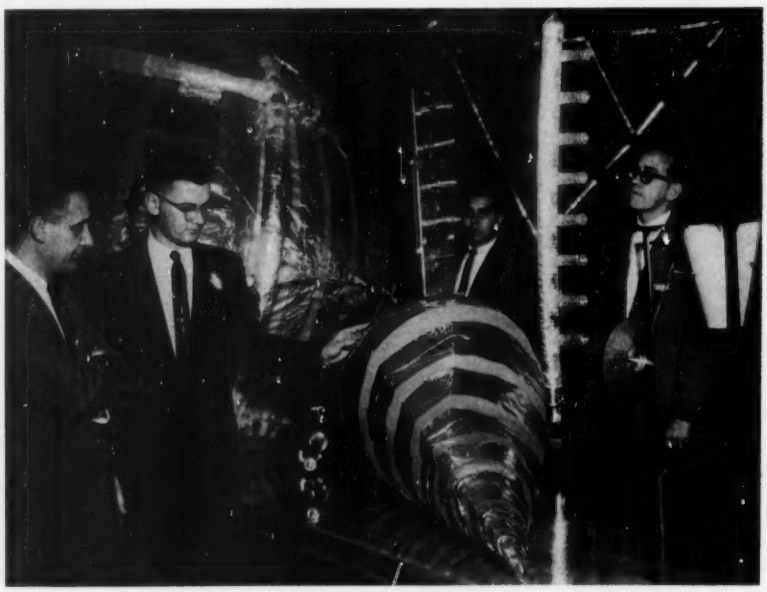
Too brittle to wind into a magnet coil, niobium is formed into a slender tube filled with powdered niobium and tin. The tube is hammered and stretched into wire, then wound into a coil and baked (above). Heat fuses the powders into the desired superconducting substance. Since pure niobium is not a superconductor in strong magnetic fields, the niobium outercovering serves as an insulator.

Space Antenna—Materials Set, Shape Undecided

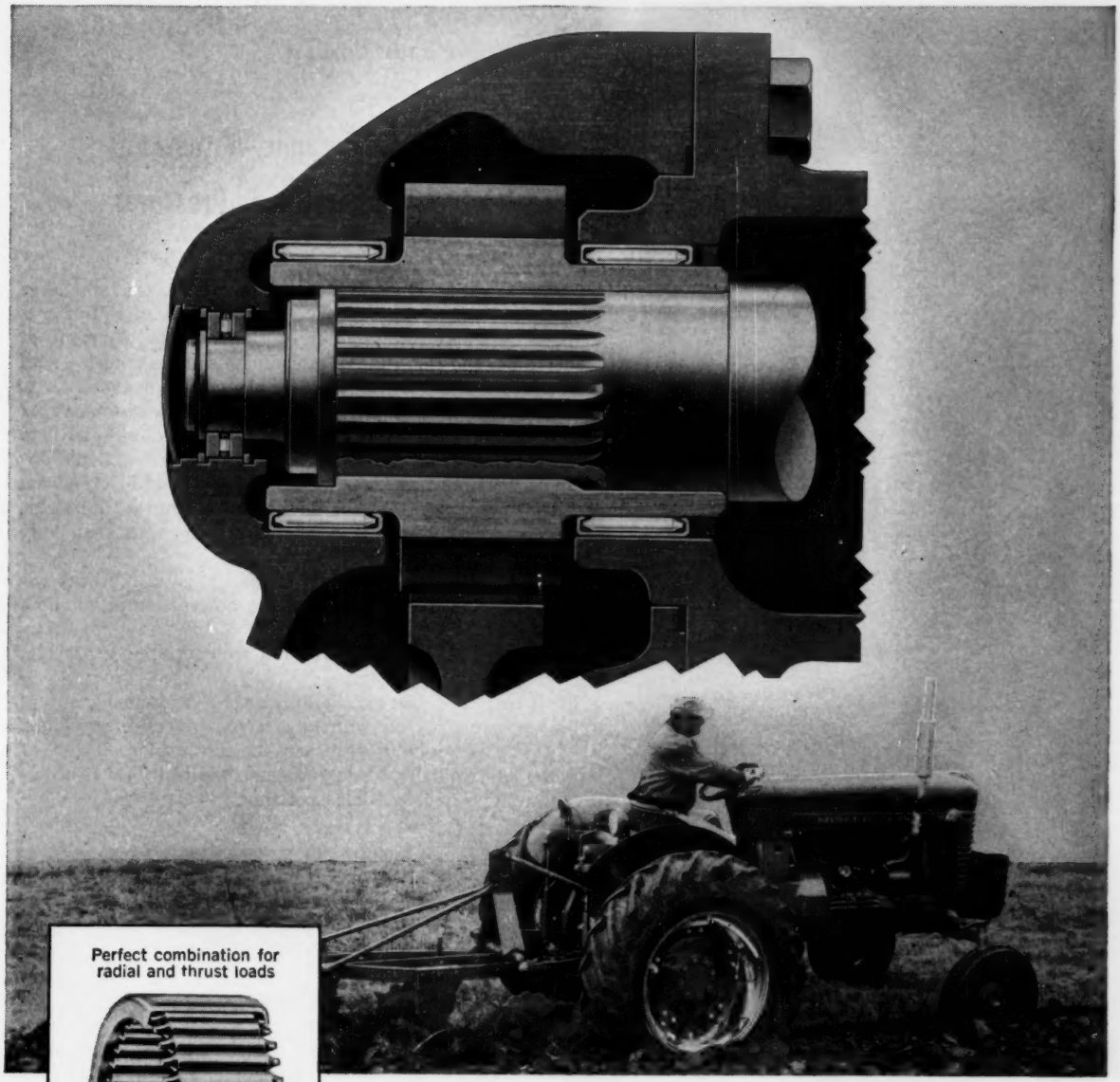
SUNNYVALE, CALIF.—Aluminum foil and plastic bags . . . at Lockheed Missiles and Space Division these are the materials from which scientists have fashioned a series of lightweight experimental spacecraft antennas for AF's Wright Air Development Division.

Designed to fold into a small compact package and then to unfurl or inflate once the vehicle is in space, the antennas are fabricated from clear Mylar film or from ordinary aluminum foil reinforced by Mylar.

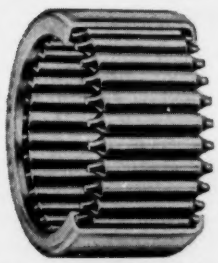
Until recently, techniques for folding and unfolding the antennas posed a major problem. While mechanically erected antennas may function best where the antenna configuration is compatible with the vehicle shape, pressure-erection techniques will be used whenever larger unfurling ratios (furled to unfurled size) are required. This technique has been proved by the successful performance of the Echo I satellite.



Spacecraft designed in the next few years will probably all follow the lead of Echo I satellite and use aluminum-foil plastic-bag antennas. However, experimental antennas now being studied at Lockheed Missiles and Space Div. vary considerably in structure. A "conical sphere," for example, resembles a Christmas tree, and the "log-periodic" is a triangular affair with elements (attached to vertical structures) radiating horizontally in a zig-zag pattern.



Perfect combination for radial and thrust loads



Torrington Needle Bearing

Torrington
Needle Thrust Bearing

For the big pull in tractor performance... Torrington Needle and Needle Thrust Bearings

On the world-famous Massey-Ferguson Model 85 Tractor more than 40 Torrington Needle Bearings and Needle Thrust Bearings are used to smooth the transmission of power, operate the power steering, and to provide improved bearing efficiency and operation.

One outstanding application is the drop axle gear set, pictured above. Here, with their full complement of small diameter rollers, two 2¾" shaft size Torrington Needle Bearings provide higher radial load capacity than any other bearings of comparable cross section. To handle the thrust load, a single Torrington Needle Thrust Bearing, with two races, is used to complete the bearing team. The result is smooth, efficient, reliable performance – at greatly reduced cost over bearing arrangements previously used in this type of application.

The combination of Torrington Needle Bearings and Needle Thrust Bearings pays off wherever compactness and high bearing capacity are needed. For advice on *your* application, call on Torrington – maker of every basic type of antifriction bearing.

progress through precision **TORRINGTON BEARINGS**

THE TORRINGTON COMPANY Torrington, Conn. • South Bend 21, Indiana

Performance Steps Up
In Metallic-Vapor Lamps

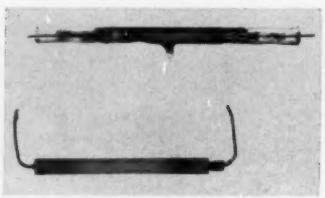
Translucent Ceramic Withstands Higher Temperatures, Pressures

CLEVELAND—Rugged new envelopes for electric discharge lamps may lead to an overhaul in the design of equipment-lighting systems. Now in early stages of development at General Electric Co., the lamps combine small size (left) with high output and extremely favorable color quality.

One experimental lamp under study is a cesium-vapor type that operates at temperatures where ordinary envelop materials (quartz, glass) would melt. With conventional envelopes, cesium vapor can't be used because it blackens the window in seconds. But the new lamp operates for hundreds of hours at an efficiency of 35 lumens per watt with very little blackening.

Key to such improved performance is a thin tubular envelope made from GE's Lucalox, a polycrystalline alumina ceramic (MD, October 1, 1959, p. 35). Because this material withstands higher pressures and temperatures, it provides several inherent advantages.

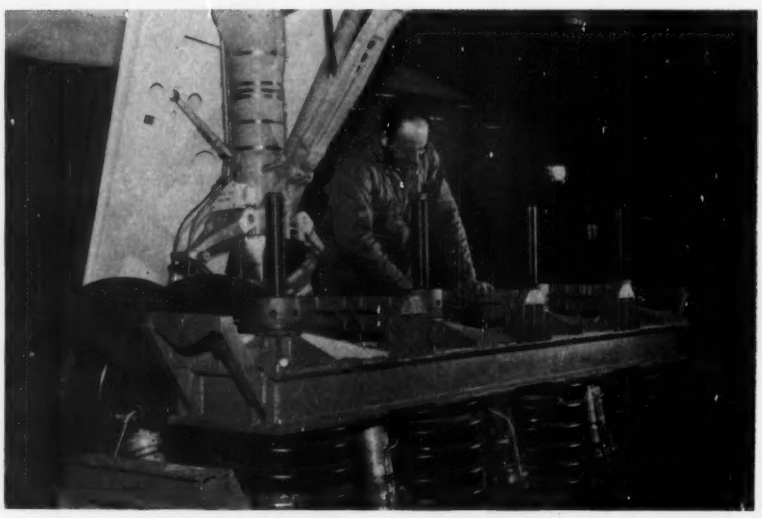
- High-output sources can be the size of a cigarette.
- Lamps operate in air without external protective envelopes.
- New vapors can be used to carry the currents.
- Better color quality because of improved distribution of energy throughout the visible spectrum.



After only 30-sec operation, cesium-quartz lamp has darkened (above). But after hundreds of hours of operation at temperatures that would melt quartz, Lucalox lamps blacken only slightly.

Testing by Trampoline

The 120-ton Convair-990 jetliner (see Picture Report, Page 24) proved to be light on its feet recently when it spent three weeks in test on this trampoline-like apparatus. Spring-cushioned isolation platforms were placed under each main landing gear and the nose gear. Testing equipment included electromagnetic drivers (mounted on wing tips, tail, and control surfaces) that shook the airplane and caused the platforms to approximate airborne vibrations. According to Convair engineers, this is only one of the many rugged tests the 990 had to pass. Designed to cruise at 640 mph, the airplane will be the world's fastest commercial jet when it goes in service later this year.



Topics

Golf is made easier than ever by a new vehicle. In the "4-Sum," two players travel trailer-style behind a Link-mobile powered golf car. Northwestern Motor Co. makes both trailer and car, which is driven by a Kohler engine.

• • •

Measurement science center, offering a program unique in the Free World, has opened at George Washington University. Eight courses will be offered in metrology, a science gaining in importance but heretofore not available as a comprehensive university program in this country. The program—offering engineering certificates or degrees of bachelor, master, and doctor of science—was organized by the university's school of engineering in cooperation with the National Bureau of Standards and with the assistance of the Martin Co. of Baltimore.

• • •

The compact moves into the kitchen in the form of a 3-ft high refrigerator. Small imported models are being used in offices, home bars, apartments, and as second refrigerators; U. S. manufacturers, noting the trend to smaller kitchens which will require smaller appliances, are building scaled-down washers, freezers, dishwashers, and refrigerators.

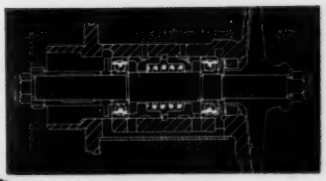
• • •

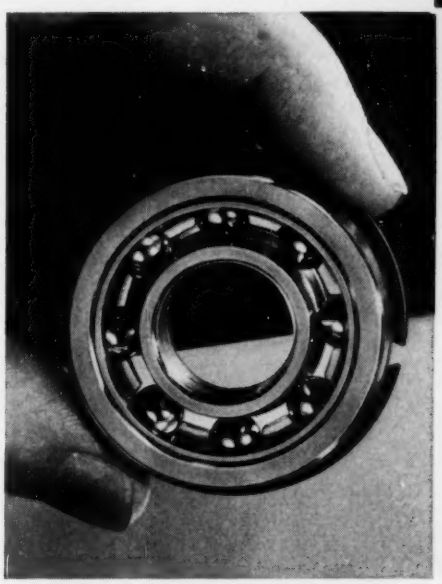
A whopper of a washer, on the other hand, will rid rocket engines up to 8 ft tall of dirt collected during manufacture and test firing. Designers at Aetron, a division of Aerojet-General Corp., are working on a machine that will measure 40 by 20 by 18 ft. It will have a receptacle to hold special detergents and will operate on the common dishwasher cycle of pre-rinse, wash, rinse, and dry. Even fussier than kitchen models, the rocket washer will rinse with demineralized water.

• • •

Fuel cells in the automotive future will eliminate the unpleasantness of exhaust and noise and reduce the number of moving parts. Housed neither fore nor aft, but in the wall of the car's body, such a powerplant would also do away with the transmission or driveshaft hump and a hard back seat situated over a transaxle driveshaft. All these wonders were proposed by industrial designer Brooks Stevens in a paper given at the January SAE meeting. Also suggested are head and tail lights composed of simple horizontal bars and orthopedic seating in a flat-bottomed passenger compartment—"an orderly bin of comfortable dimensions."

1,200,000 DN TURBINE BEARING OPERATES AT 600° F





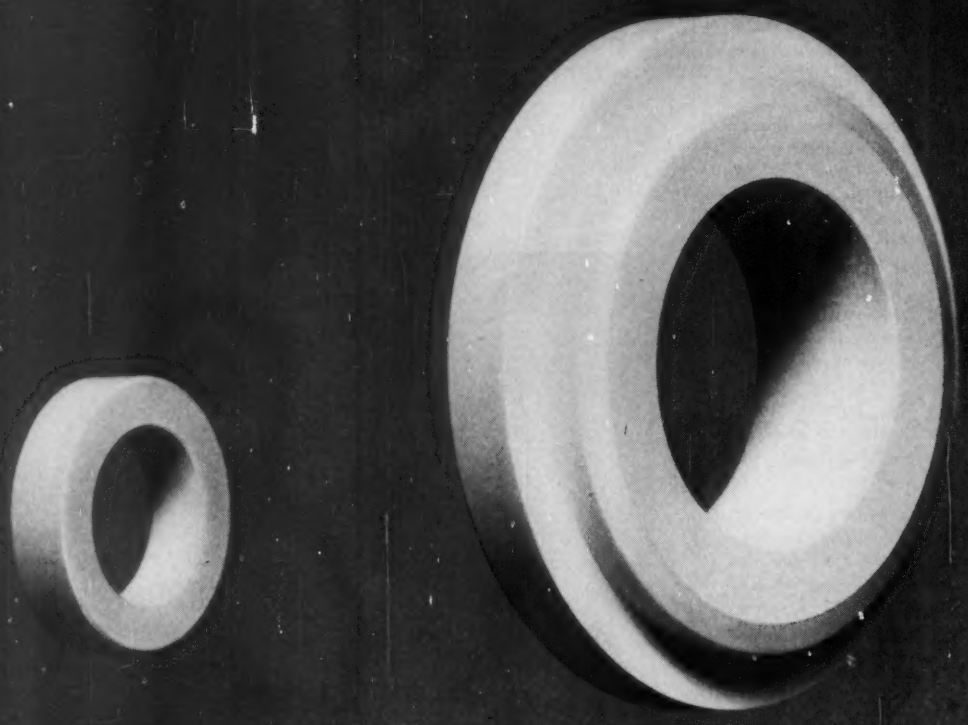
ITI

Turbine shaft speeds up to 60,000 rpm and 900° F exhaust gases were the severe service conditions ITI engineers had to consider in designing turbine bearings for the Sunstrand Model 871 flight vehicle power unit. By custom-engineering tool steel ball bearings with strong, lightweight separators, and then pre-loading them in a reversible thrust-type mounting, ITI was able to increase useful operating life from 2 to 75 hours. Complete technical data on this unusual high temperature bearing is available in Tech-Tonic #3, or for information on how ITI can design and produce in quantity other special bearings having corrosion resistance, extreme precision, or unusual configuration, write for Bulletin AFB-2.

INDUSTRIAL TECTONICS, INC.

manufacturers of precision balls and bearings

BEARING DIVISION | 18301 SANTA FE AVENUE, COMPTON 2, CALIFORNIA



Tractors or Reactors

From tractor water pumps to atomic reactors, Coors Ceramic has proved itself to be an ideal material for mechanical shaft seal rings. From workaday to space age applications...the extreme resistance to abrasion and corrosion of this material offers long, trouble-free service life. Coors Ceramic is also used where price is a factor, as in dish washers and other appliances. Write for Design Data Sheet 5002 for a complete story of Coors Ceramic in seal rings. Or call your nearest Coors Regional Sales Manager: WEST COAST, *William S. Smith, Jr., EM 6-8129, Redwood City, Calif.;* MIDWEST, *John E. Marozeck, FR 2-7100, Chicago, Ill.;* CENTRAL, *Donald Dobbins, GL 4-9638, Canton, Ohio;* EAST COAST, *John J. McManus, MA 7-3996, Manhasset, N. Y.;* NEW ENGLAND, WARREN *G. McDonald, FR 4-0663, Schenectady, N. Y.;* SOUTHWEST, *Kenneth R. Lundy, DA 7-5716, Dallas, Texas;* OIL FIELD INDUSTRY, *William H. Ramsey, UN 4-6369, Houston, Texas.*

Coors

ALUMINA CERAMICS

Coors Porcelain Company

600 NINTH STREET • GOLDEN, COLORADO

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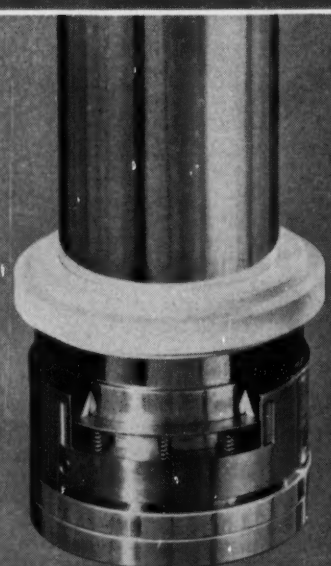

SEAL ASSEMBLY CUT AWAY

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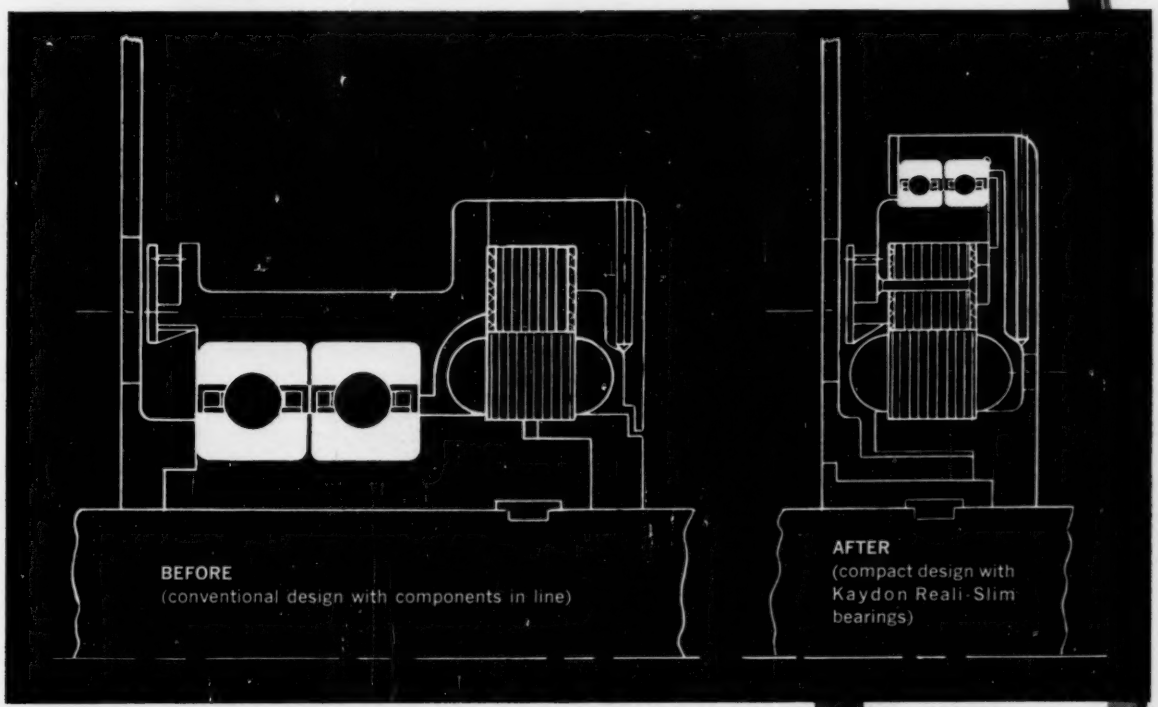
Don't let in-line design get in the way of a compact product...

"NEST" COMPONENTS INSIDE THE BEARING BORE



Motor assembly redesign shown above is typical of the way Kaydon Reali-Slim bearings save space, reduce weight, cut costs!

Kaydon thin-section Reali-Slim bearings provide valuable component space inside the bearing bore. And use of a hollow shaft permits utilizing this space for control rods, linkages, collets, counter-rotating shafts, clutches and brakes, to name a few possibilities.

With Reali-Slim bearings, you save weight and space in both bearing and housing, reducing costs for materials, shipping, storage and handling.

And large-bore Reali-Slim bearings give closer support to the outer edge of rotating parts, instead of the center only, which gives more rigidity and accuracy for moment loads.

Stocked in 90 sizes! These Kaydon Reali-Slim Type CP bearings have Conrad deep-groove, ball-radial construction and new bronze, one-piece snap-over separator in 4" to 12" bore—¼" to 1" width and cross section. Kaydon's volume production cuts prices up to 76%, depending on size.

Contact Kaydon now. Have the Kaydon sales engineer or distributor salesman in your area discuss Reali-Slim bearing applications for *your* products. Or write for free, fact-full "CP" bearing bulletin—with prices.

Shown here is an actual size KA-90-CP bearing, with 9" bore, ¼" cross section and ¼" width

20TH YEAR 1941 KAYDON 1961 PRECISION

THE KAYDON ENGINEERING CORP.

•MUSKEGON, MICHIGAN

All types of ball and roller bearings — 4" inside diameter to 178" outside diameter . . . Taper Roller Roller Thrust • Rolier Radial • Needle Roller • Ball Radial • Ball Thrust • Four-Point Contact Bearings

K-609R

NEWS TRENDS

pilots move out of the red

Red-illuminated cockpits in Air-Force jets are on the way out. Long used because it supposedly hurried pilot adaptation to night vision, red lighting shows only black and red instrument markings. However, human-factors engineers recently satisfied themselves that adaptation time was entirely acceptable for low-intensity white light, and white light lets the pilots distinguish all colors on instruments and maps. Northrop's T-38A supersonic trainer is the first production military aircraft to make the changeover.

road blocks for fuel-cell autos

Electric autos powered by fuel cells are technically feasible now, says M. Eisenberg, Lockheed Aircraft Corp., Missiles and Space Div., but they won't be economically feasible for some time to come. Fuel cells must be developed that operate efficiently with conventional inexpensive fuels. Hydrogen-oxygen cells, the best understood systems being studied, cost considerably more to operate than internal-combustion engines, and there are other problems too. Gaseous hydrogen needs high-pressure containers, saddling a vehicle with a high tank-weight to fuel-weight ratio. Liquefied hydrogen would require a constant boil-off, which is incompatible with intermittent use of a vehicle.

NEMA prepares for the exotics

New electric-power sources are developing so fast that the National Electrical Manufacturers Association has deemed it time to form a new section. Now being organized, the Unconventional Power Generation Section will ride herd on fuel cell, thermoelectric, thermionic, MHD, photovoltaic, and photochemical developments. Early tasks for the Section will include establishing standards for basic terms, definitions, and tests. A five-man committee is preparing recommendations on other proposed activities.

ostracizing the imports

The U. S. electronics industry has a new ally in its battle against imported tubes, transistors, and other components. Local 1031 (Chicago) of the International Brotherhood of Electrical Workers Union says its members will not work with Japanese parts after May 1, 1961. Membership in the union has dropped to half in the last few years, and, according to Local 1031 president M. Darling, "we will not remain passive and helpless as working standards erode and jobs disappear."

'instant' computations

Electrical circuits have been devised that will operate at near light speed. Designed for use in an ultrafast computer that Radio Corp. of America is developing for the Navy, the new circuits can do their jobs "100 times faster than others in existence and up to 1000 times faster than circuits in most data processors now in use," says Donald H. Kunsman, RCA vice president. The development is expected to be the key to "instantaneous" computers of miniature size. Such equipment could do 30 minutes of work (by today's computer standards) in less than two seconds.

for truck-trains: turbines or diesels?

Truck-trains will be operating on superhighways by 1975, J. C. Wagner, International Harvester Co., predicted at the last SAE meeting. The gas turbine—which should appear on commercial trucks by the end of the '60s—and advanced diesel engines are the likely candidates to power the tractor. The turbine has the edge, however, because it's smaller than the diesel in truck-train horsepower ranges. On the other hand, individual units of the train might be self-propelled and remotely controlled from the lead unit. In this case, small diesels might be sufficient.

uptown chain reaction

Last month Columbia University became the first school in the greater New York area to purchase a nuclear reactor. Other subcritical reactors are available in the city (for teaching purposes), but until Columbia contracted for a Triga reactor (marketed by General Dynamics Corp., General Atomics Div.) there was no equipment that could initiate a chain reaction. According to GD, nuclear reactors could not be installed in populated areas until recently when the inherently safe, self-regulating Triga series was developed.

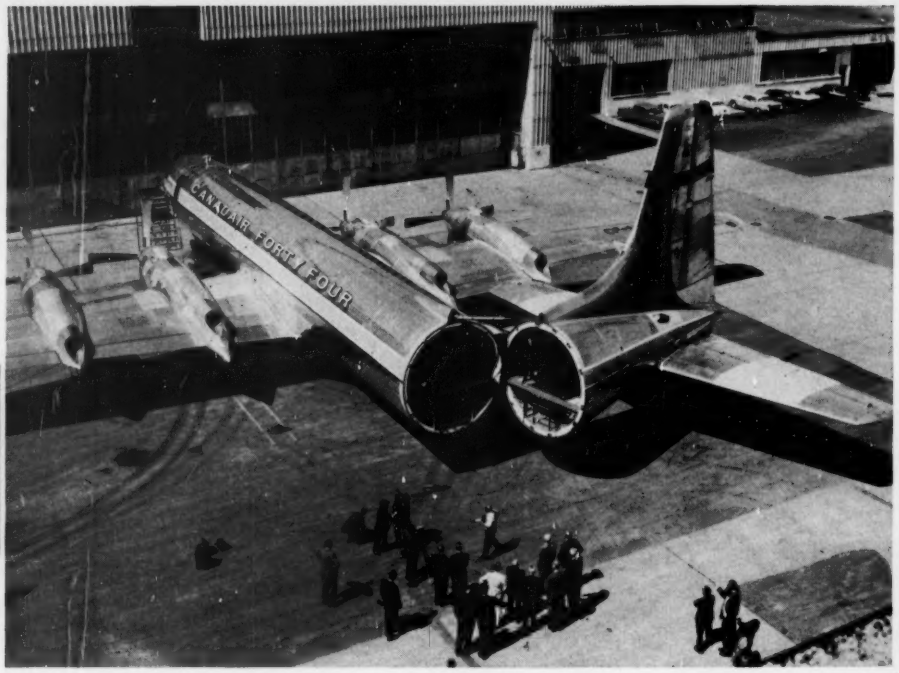
professional name calling

Names Inc., a new subsidiary of the industrial design firm of Lippincott & Margulies, Inc., has been formed to help corporations name their new products. First organization devoted to this task, the new company will collect, screen, and evaluate names for marketing purposes and supervise the legal activity required to obtain and clear them. A program of research on customer reactions to different names is also planned.

Maximum cruising speed is 640 mph in the Convair 990, a "second-generation" jet airliner whose design was begun after present jets were flying. The 990's wings are thinner than those of any other transport, and the 39-degree sweepback is greater than on other jet airliners. Enclosed in new type pods, GE CJ-805-23 aft-fan engines each provide 16,100 lb of thrust.

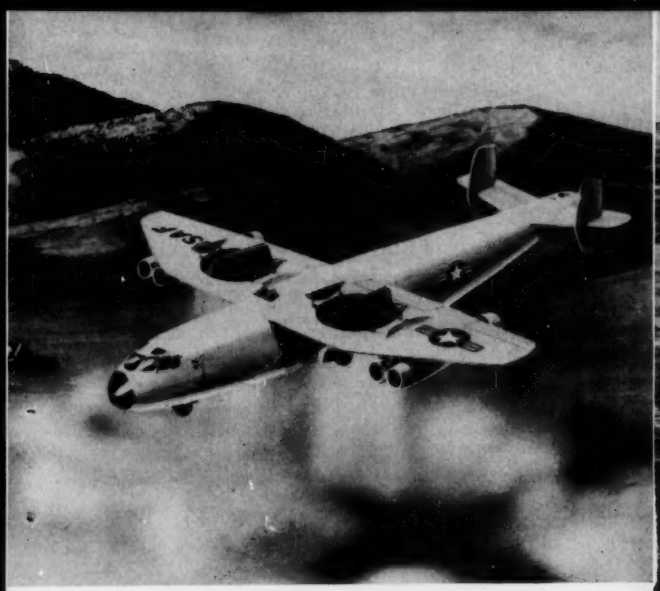
ENGINEERING NEWS

PICTURE REPORT

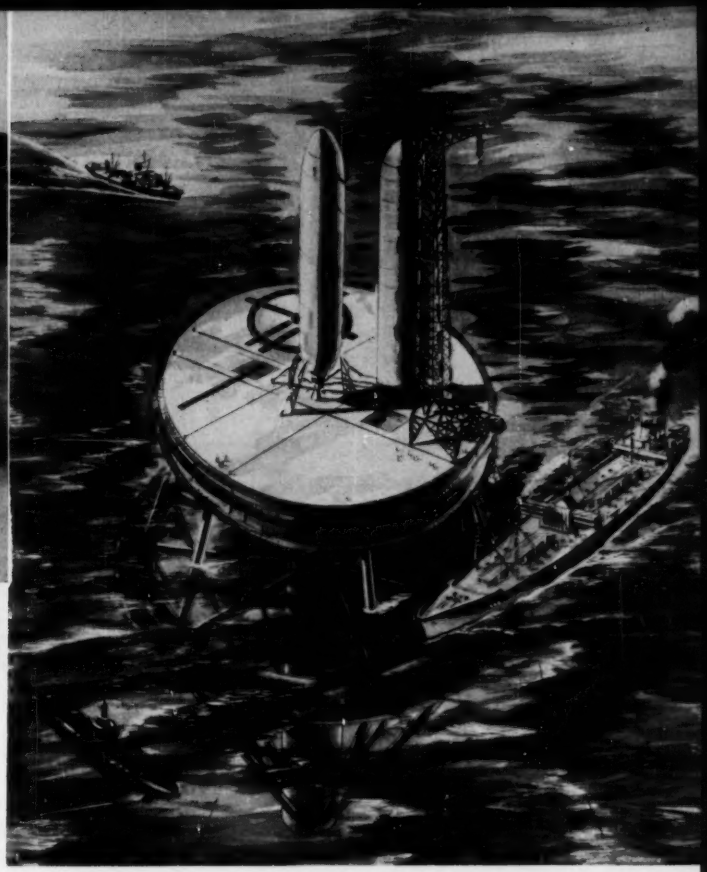


Straight-in loading of over 33 tons of cargo is done quickly and easily in Canadair's Forty Four. This is not only the first swing-tail aircraft, but the first plane of any kind designed specifically as a cargo carrier. Fully loaded, it has a range of over 3000 miles at a cruising speed of 394 mph. Tail can be opened, or closed and locked, in 90 seconds.

Pleasure boating without a hitch (or car, trailer, ramp, or wet feet) is the tantalizing prospect offered by the Heli-Bout, a "prophetic boat design" by Brooks Stevens for Evinrude Motors. The idea is to drive a helicopter rotor with a 75-hp outboard motor through flexible shafting and reduction gears, providing a craft that will go directly from the back yard to the water. The Heli-Bout has a 12-ft hull and is 16 ft overall with stabilizer fins. Its two-place cockpit is instrumented like that of a helicopter.



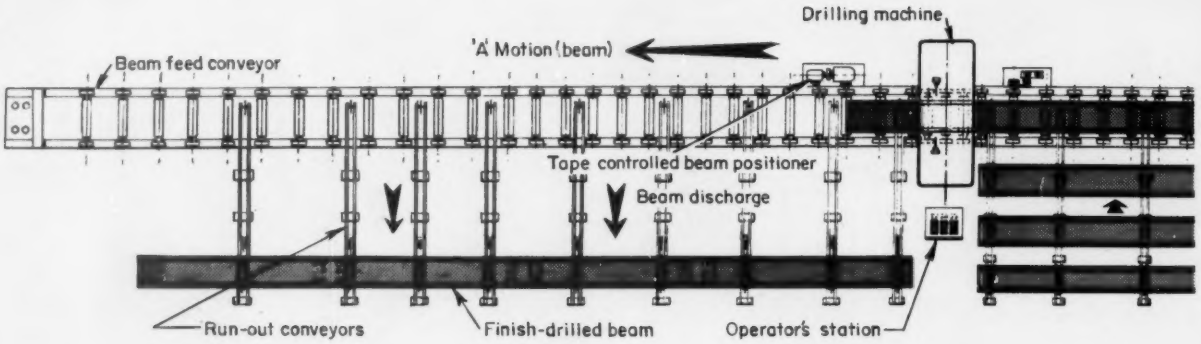
A VTOL military transport plane is suggested by engine aerodynamicist Elliott Kazan, Republic Aviation Corp., for use at air bases with limited facilities. Power for the transport would be supplied by six turbo-jet engines. It would be able to attain altitudes up to 3600 ft and have a ferrying range of 3000 miles.



Launching at sea is proposed by Aerojet-General Corp. for large chemical and nuclear-rocket boosters. PROP (Planetary Rocket Ocean Platform) would provide a buoyant sea-base for fabricating, assembling, and static testing as well as launching. Designed for extremely good stability, even during a hurricane, PROP is supported by a buoyant underwater chamber; its launching platform is located above the reach of high seas. After a nuclear launching, personnel could be evacuated by a submarine to avoid exposure to radioactivity.

Personal monorail car would travel on the highway as well. The XV'61, designed for McLouth Steel Corp., is a four-passenger, 90-in. wheelbase vehicle which utilizes stainless steel in unit body construction, interior and exterior panels, window pillars, integral rocker panels and door sills, bumpers, and exhaust system. To travel on a monorail system, it would be secured to a pod, which would be positioned on a track then sent—at 100 mph—to a predetermined destination. McLouth calls the XV'61 a "concept," but points out that if a monorail system were in existence now, the car could be built.

Four thermoelectric power generators, demonstrating the range of output available from such devices, have been built by Westinghouse Electric Corp. in ratings of 5, 10, 50, and 100 w. Basic output of the 5-w generator is 1.7 v at 4 amp; that of the 100-w model is 9.4 v at 13 amp. The generators can be designed to use any type of fuel and any type of cooling medium. They operate at a core temperature between 300 and 600 C, depending on application and type of fuel used.



Tape Builds a Bridge

BRIDGE building and tape-controlled machining—oldest and newest of the engineering arts—have joined forces to produce a major innovation in the fabrication of structural-steel components. The New Albany Bridge (now being erected across the Ohio River) is the first to be built with 100,000-psi yield strength steel; it also marks the first use of a numerically controlled drill in bridge fabrication.

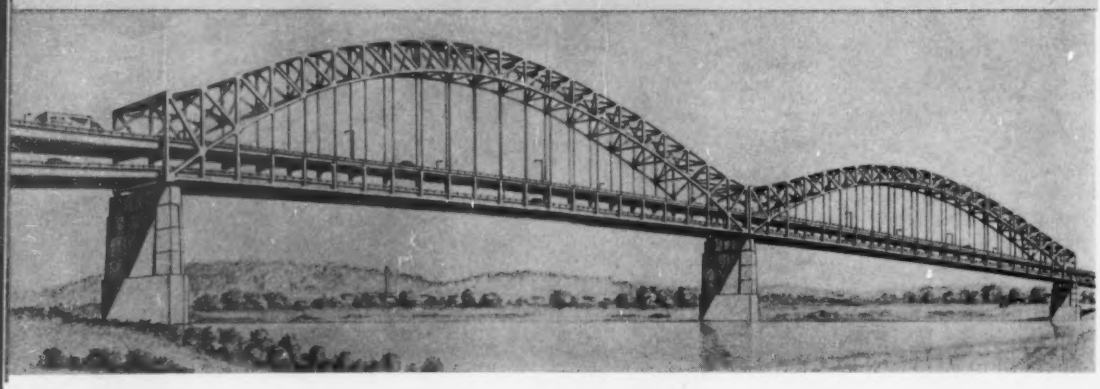
The new automated machine (sketch, above), in its first application at R. C. Mahon Structural Steel Div., Detroit, cuts 85 per cent from the cost of prefabricating beams and columns by manual-layout punch or drilling techniques. According to Mahon, the high accuracy and hole-pattern repeatability offered by tape-controlled drilling will eventually eliminate all expensive hole reaming on the assembly floor.

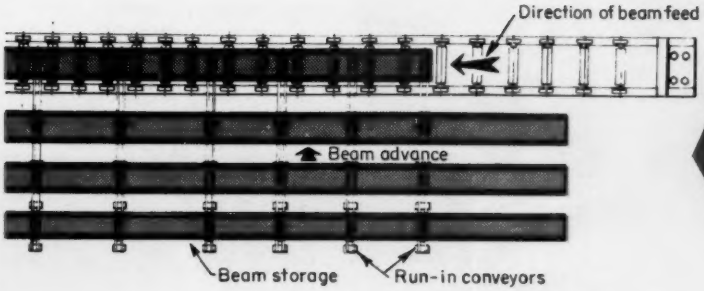
Built to handle beams up to 80 ft long, the Mahon installation integrates the motions of a motorized run-in conveyor, beam-fed conveyor, high-speed drilling machine, and run-out conveyor. First in a new line designed by Walter P. Hill Inc. for the steel-fabrication industry, the drill uses opposed horizontal spindles and a vertical spindle to drill ¾-in. diam holes at feeds up to 30 ipm.

In the operating sequence, beam sections are first crane loaded on the run-on conveyor. By pushbutton control, the operator moves one beam at a time onto the beam-feed conveyor. The tape-controlled beam-feed (A-motion, above) combines a carriage for feedback control with a main conveyor roll drive for moving the beam. Rolls are powered by a dc motor which drives through a continuous chain drive. The carriage, rolling on wheels at the edge of the machine, has a finger that contacts the end of the beam and is thus pushed along by the beam.

To remove any chance that beam slippage on the

Designed by Hazelet & Erdal, the $15 million New Albany Bridge exhibits the latest techniques in design, use of materials, and fabrication. Low-alloy, high-strength steel (T-1 and N-A-Xtra 100) was considered mandatory in the tie arch. All major components are welded, and high-strength bolts are used for field connections.



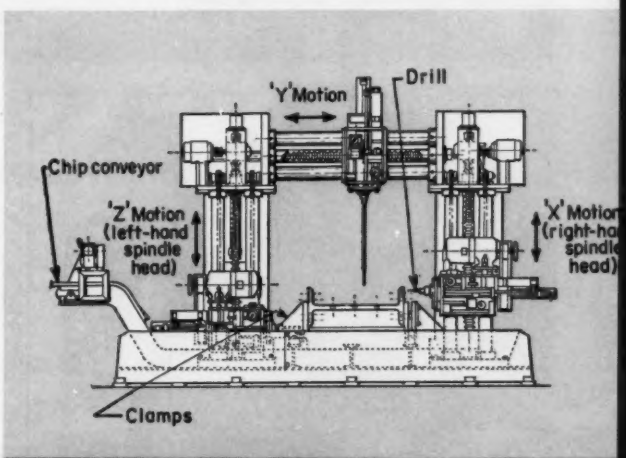


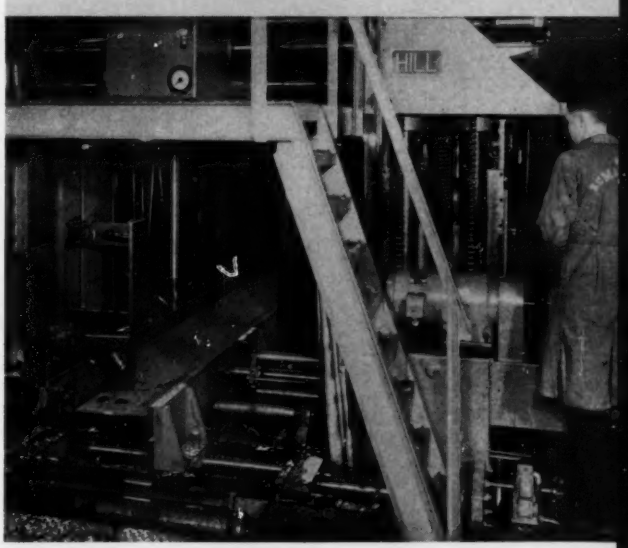
Control console of the Hill tape-controlled drill is designed for one-man operation. General Electric Mark IV numerical positioning control (not shown) monitors A-motion advance of each beam and X, Y, Z motions (plus feed) of the three drill spindles.

Automated line cuts 85 per cent from beam-drilling costs

conveyor rolls will affect A-motion accuracy, a small motor—driving through a hydraulic coupling—applies a light torque to the feedback carriage in the direction opposite to feed-roll motion. Carriage (and beam) position is transmitted by a selsyn unit.

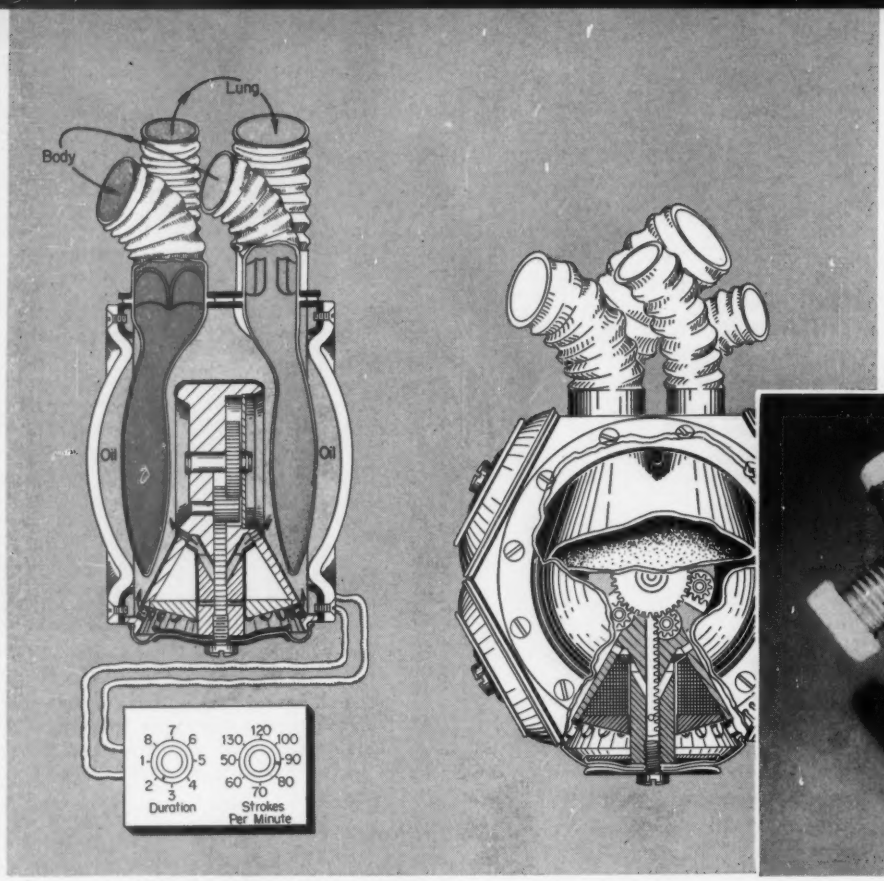
Pushing the cycle-start button causes the tape reader in the control console to read the first block of information on the tape—including dimensions for all four machine motions, as well as auxiliary code information for each drill head. The machine immediately moves to a command location, with all motions occurring simultaneously. After the A-motion co-ordinate is established, beam clamps are actuated. When drills begin to move in, the next block of tape information is read and stored until needed by the machine. The operator discharges the beam for temporary storage on the run-out conveyor after the hole pattern is completed.



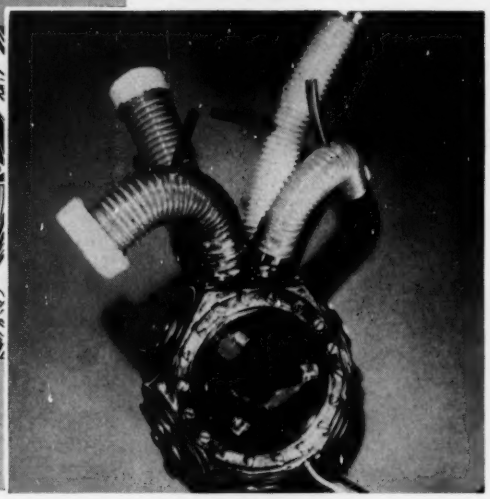


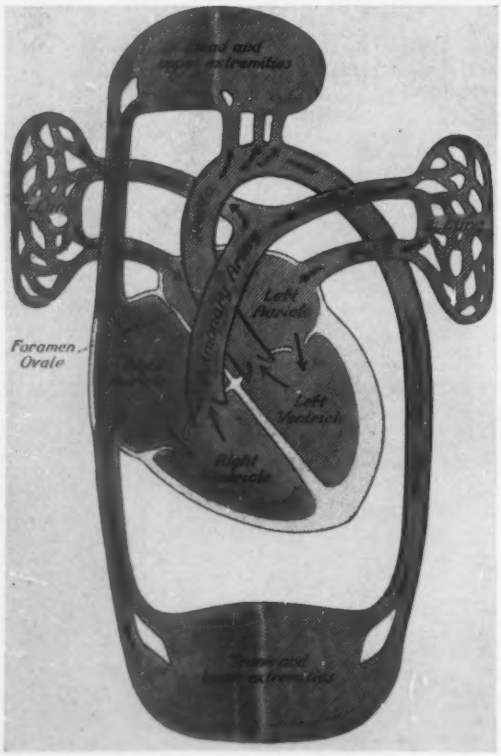
X, Y, and Z motions for the Hill-developed three-spindle automatic drill (right) are identical. Drive for each head includes a hydraulic cylinder (which provides "muscle" to move the head), ball-bearing lead screw (driven by a worm-gear speed reducer), selsyn pickup (back-connected to the lead screw), and a 3/4-hp dc positioning motor. The lead screw unlocks when the positioning motor is actuated, and the hydraulic cylinder moves the head to the position dictated by the tape.

Tape, dial, and manual control options insure flexibility in the Mahon installation. Dial operation permits random holes (not in the programmed tape) to be accurately positioned and drilled in a beam. Manual control allows the operator to jog the drill in forward or reverse directions outside of the automatic drill cycle. To take care of structural member mill variations, floating zeros (to 0.040 in. on all motions) permit establishment of new or different reference points.



Magnetic heart, one of Norton's early designs, functioned well despite seeming complexity. Five solenoids attached to diaphragms and coordinated by rack-and-pinion arrangement provided pumping action. Oil transferred pressure evenly from pumps to ventricle sacks.





Actually a double pump (each half of the heart consists of an antechamber called the atrium (auricle) and a ventricle) the heart operates with a weak suction stroke, but a very strong pressure stroke. Thick muscular walls of the ventricles are largely responsible for the pumping action.

Off-the-Shelf:

The

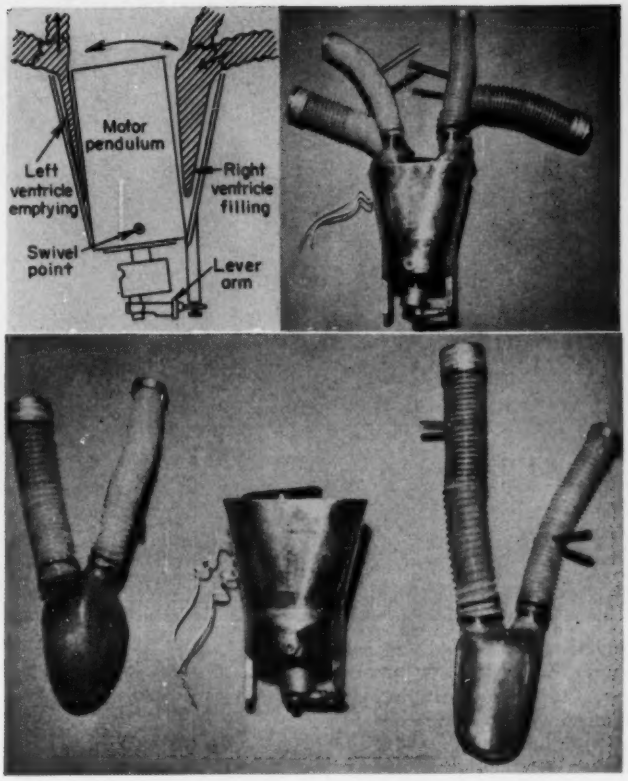
DESIGN a permanent heart substitute? The first reaction is usually one of technical incredulity. But closer study, from an engineering standpoint, seems to indicate that the project is merely a straightforward exercise in pump design: Flow rates are high, but feasible; pressures are low, and an unpatented working model of the end product is readily available, to be copied with a clear conscience.

This, according to S. Harry Norton, a semi-retired Cleveland engineer, is how things now stand in a project in which he has been engrossed for the past three years. Norton assists a group of doctors at Cleveland Clinic who have gained considerable prominence in medical circles for their progress in developing an artificial heart.

The idea that a permanent heart substitute is impossible soon disappeared, says Norton. So did the idea that the human heart is an ordinary pump.

In the first place, work done by the heart is all out of proportion to its size. It pumps 75 gallons per hour while the human body is sleeping; up to 14 barrels per hour during strenuous exercise. An output of some

As a design goal, the human heart sets a pretty high standard. The most obvious problem: Designing a pump to operate continuously for 70 years. This might be solved by building replaceable models "guaranteed for five years." But then there is a matter of control: How will a mechanical pump be made to respond to emotion?



Pendulum heart, one of the first heart substitutes developed at Cleveland Clinic, empties ventricles alternately in contrast to action of the human heart. The device is powered by a small ac motor coupled to a gear reducer. Motor-pump arrangement, suspended by pivots, swings back and forth within the rigid housing, alternately compressing each ventricle against one side of the housing. Ventricles and valves are made of polyurethane, which has proved highly successful in replacing the real thing. The heart, placed in an anesthetized dog, kept the animal alive 5 hours.

Mechanical Heart

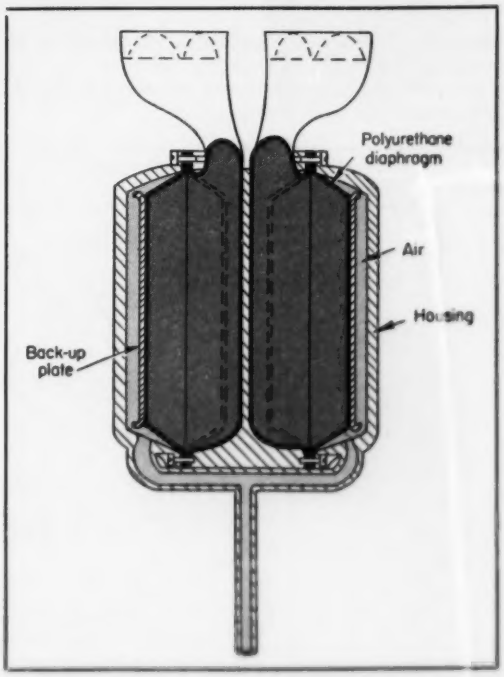
70 barrels is normal for an average 24-hour day. All of this is accomplished without overheating, with a remarkably small power input, and with extreme reliability. These mechanical virtues are, of course, enhanced by a control system that probably defies duplication.

Nonetheless, the heart is still basically a pump, and by keeping this fact in mind the Cleveland medical-engineering team has produced a number of workable heart substitutes.

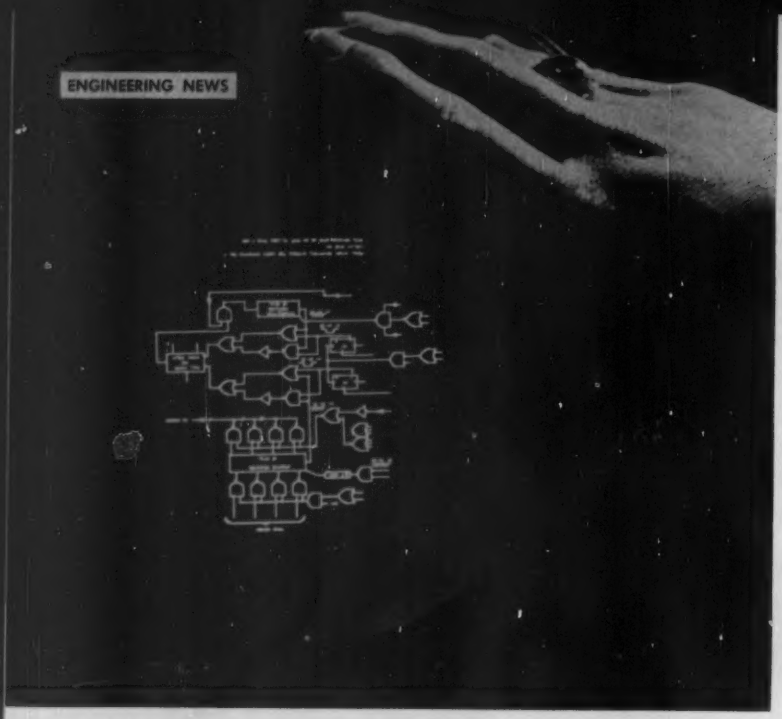
All designs to date depend on external electrical power sources and controls. Two wires, emerging from the chest cavity, connect to batteries and/or 110 v.

Present emphasis is centered on air-operated mechanisms powered by electric-motor-driven pumps. The pneumatic mechanisms are smaller, run cooler, need less power, and are generally less complicated than hydraulic or straight mechanical versions.

Work with the heart substitute thus far has been confined to animals; success has been measured in hours. But with each new design, reaction of the "patients" has been more nearly normal; time has substantially increased.

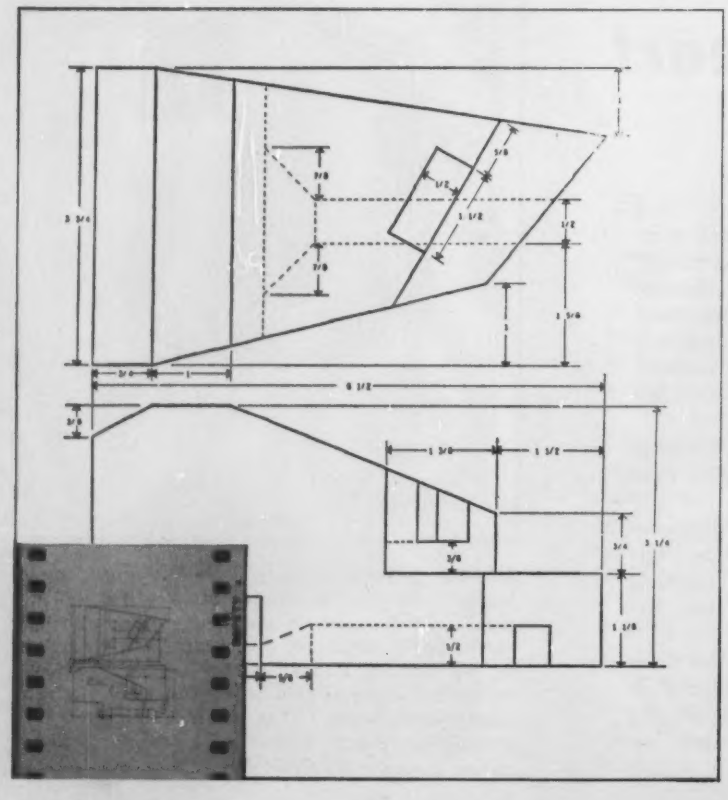


Air Heart, being designed by S. Harry Norton, is much simpler than previous heart substitutes. External air supply will be used in preliminary tests, although Norton has a completely automatic closed air system on the drawing board. Almost entirely "built-in," the system would require only an external electrical supply—batteries or 110 v—for a miniature electric-motor-driven pump. Pressurized air bottle could be carried in event of all-out electrical failure.



Logic-circuit diagram was automatically drawn with electron beams. The display is presented on the face of a 7-in. beam tube, and the system records the drawing on 35-mm microfilm, all within half a second.

After the engineering drawing is photographed on microfilm (lower corner), any size prints can be made. The electronic technique produces excellent quality drawings in a fraction of the time needed by human draftsmen.



Electronics Takes Up Drafting

Computer-Driven Recorder Makes Split-Second Drawings

SAN DIEGO, CALIF.—Using information in mathematical-code form supplied by a computer, a new microfilm recorder "pencils" in (with a beam of electrons) lines, curves, symbols, and dimensions. Finished drawings are turned out in less than half a second.

Developed by Stromberg-Carlson Div., General Dynamics Corp., the recorder, called S-C 4020 High-Speed Microfilm Recorder, displays an image of the drawing on the face of a Charactron Shaped-Beam Tube, the heart of the microfilm printer. Working prints are obtained by photographing the display on 35-mm microfilm. After the computer is programmed with contours and specifications of the part to be designed, the recorder can make drawings of any view or cross section.

Electronic Double-Checking

According to S-C, the unique automatic-drafting concept will substantially reduce drafting and design time and eliminate many mistakes common in automated manufacturing. Drawings are made from the same computer code that produces the tapes which operate automatic-production equipment. Mistakes can be avoided by checking drawings before work actually starts on the part.

The electronic draftsman can also draw complex wiring diagrams and do layout work that requires calculations. Originally, the units were designed as readout equipment for computers and as data plotters. Their capabilities include recording data on microfilm at 17,500 points per sec, plotting graphs at 12,500 points per sec, recording complex logic drawings, and doing tabular printing. Business headings or forms may be superimposed, along with the data on any frame of film.

ENGINEERING NEWS-#4

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high current capacity in tiny case.
excellent shock and vibration resistance.
solder terminals, others on request.
25,000 ops. min per MIL-S-6743.
7.5 amps @ 125/250 VAC, 60 cycles Ind. & Res.

ideal for compact, precision control uses...

E4 SERIES

SUBMINIATURE, SPDT, 23/32" x 1/4" x 23/64"
low movement differential and operating force permit precision control in critical applications.
solder; single, double and long double turret terminals.
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for rugged, low-cost, easy wiring uses...

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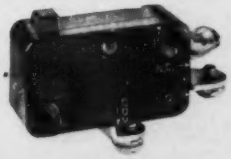


MINIATURE, SPDT, 1 3/32" x 13/32" x 5/8"
rugged, low-cost design.
convenient terminals simplify wiring.
solder, screw and spade terminals.
150,000 ops. 10 amps @ 125/250 VAC, 28 VDC Res.

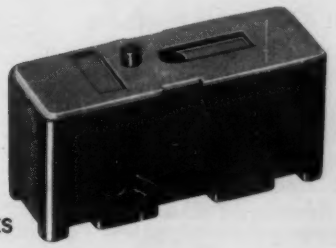
good for power circuits, precision control uses...

S SERIES

2-CIRCUIT, SPDT double break, 1 1/4" x 1/2" x 1/2"
combines high capacity, moderate size, long life and precision control.
tested to 10,000,000 operations.
end and side solder, screw and spade terminals.
750,000 ops. @ 125 VAC, 10 amps., U.L. rated.

for general purpose, high in-rush and repeatability uses...

S2B SERIES



SPDT, 1 15/16" x 1 1/16" x 57/64"
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handles high in-rush loads easily.
repeats to 10,000,000 cycles min.
screw terminals.
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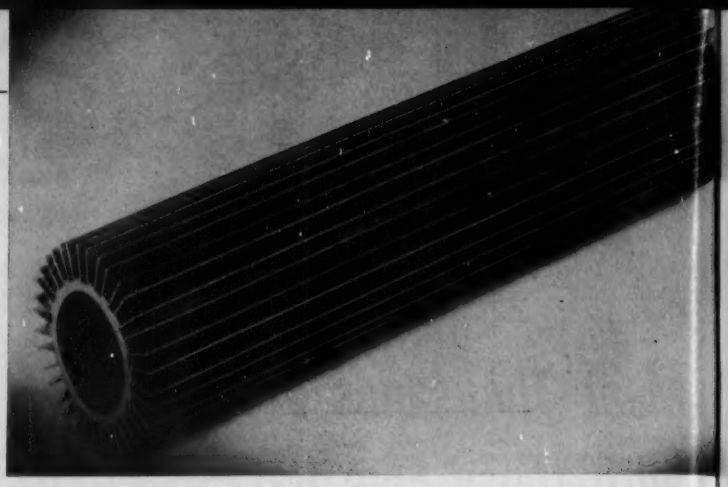
Circle 414 on Page 19

ENGINEERING NEWS -- Basic Precision Switches

Interim Report:

Stainless Mild Steel Proves Its Mettle



By changing materials (from ceramic-coated to chromium-diffused steel) one manufacturer upgraded his heat exchangers for continuous operation at 1600 F. The new steel has proved highly successful in heating-equipment design because of its excellent resistance to oxidation and scaling at high temperatures.

WILMINGTON, DEL.—About a year ago, a new process was reported to give stainless properties to low-carbon steel. Developed by Alloy Surfaces Co., the process (called Alphatizing because chromium is diffused into the surface of mild steel, stabilizing the "alpha" crystalline form of iron) creates a true metallurgical alloy; surface chromium reaches 40 per cent or higher.

Industry has now had a chance to experiment with the chromium-diffusion technique; in some cases, data have been startling:

- A truck muffler is still serviceable after 500,000 miles.
- An automobile manufacturer is so impressed with the new design material that production of an Alphatized-steel engine part is slated to start next month.

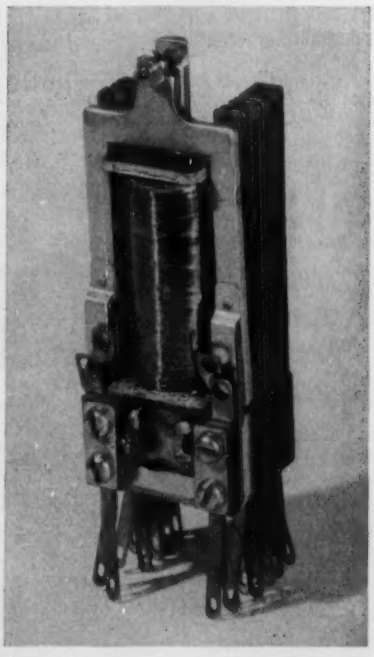
Experimental truck muffler outlasted several tractors. After 500,000 miles of service, it has not yet been eaten out by exhaust acids.

Results: Good Across the Board

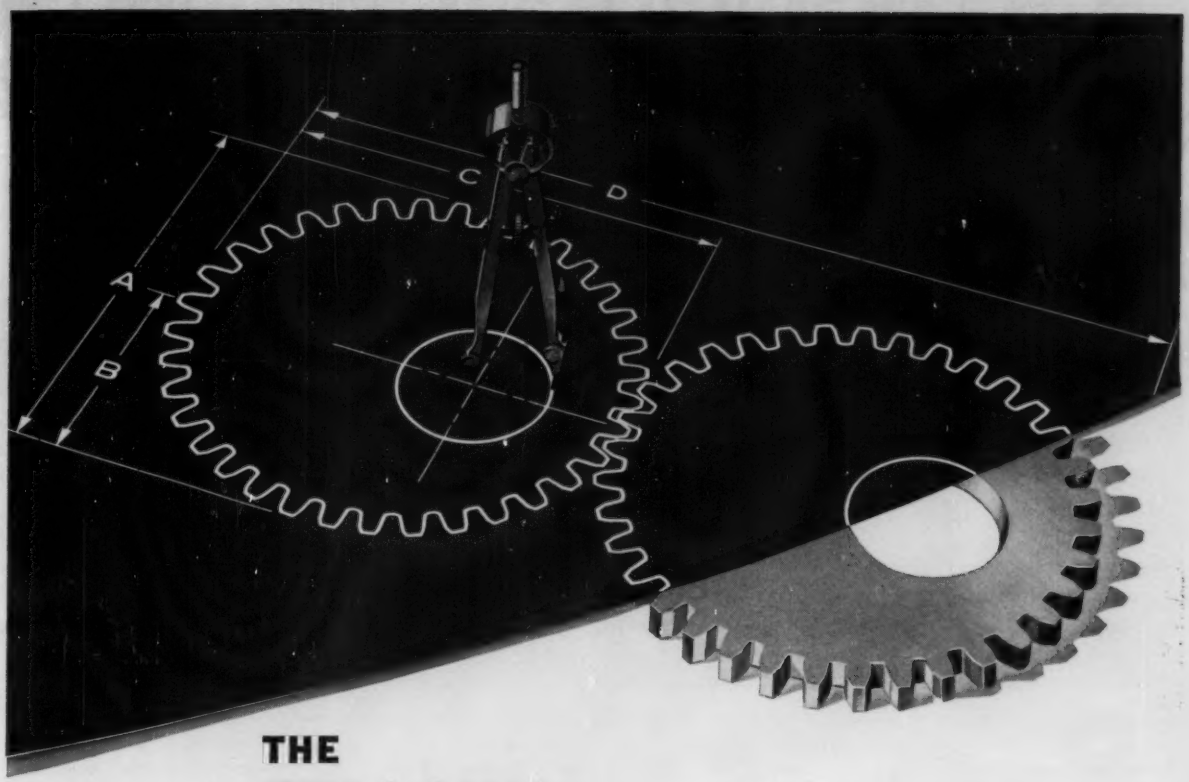
Critical parts in a wide range of products are being redesigned with Alphatized steel because, according to ASC spokesmen, stainless properties can be achieved at a fraction of the cost of standard stainless steels. Advantages cited for the material include the following:

- Oxidation resistance at high temperatures. Heater manufacturers have been able to boost operating temperatures from 1000 to 1400 F by replacing ceramic-coated steels with the new material. Ordnance-Tank Automotive Command, Detroit Arsenal, has approved the steel for exhaust systems on both wheeled and tracked vehicles (including deep-water fording equipment).
- Corrosion resistance. One truck manufacturer is planning a line of Alphatized mufflers with a guaranteed service life of 100,000 miles. Steels with 40 per cent surface chromium are practically unaffected by nitric acid, sulfur-containing materials, and weather corrosion.
- Magnetic properties. Alphatized 1008 steel has virtually the same magnetic properties as annealed magnetic ingot iron. Relay manufacturers are now making components from the material, eliminating chrome plating.
- Surface hardness. Service life of steel crimping rolls used to seal cans was increased 1600 per cent. Wear resistance (and corrosion resistance) of powdered metals is greatly improved (the process seals pores of powdered-metal parts).
- Weldability. Unlike aluminized and other coated steels, the new material can be welded in all the common ways.

Diffusion of chromium into metal has been in the developmental stage since 1920. The new technique, a gaseous process, eliminates many disadvantages of earlier methods.



By Alphatizing magnetic parts of this dc relay, the manufacturer was able to cut costs. The new steel eliminates need for premium-grade iron and for electroplating the contacts.



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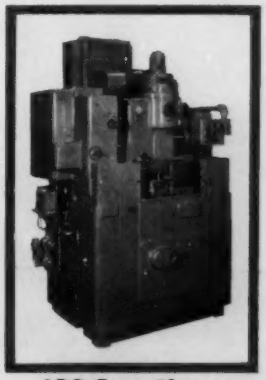

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Gear Production Equipment

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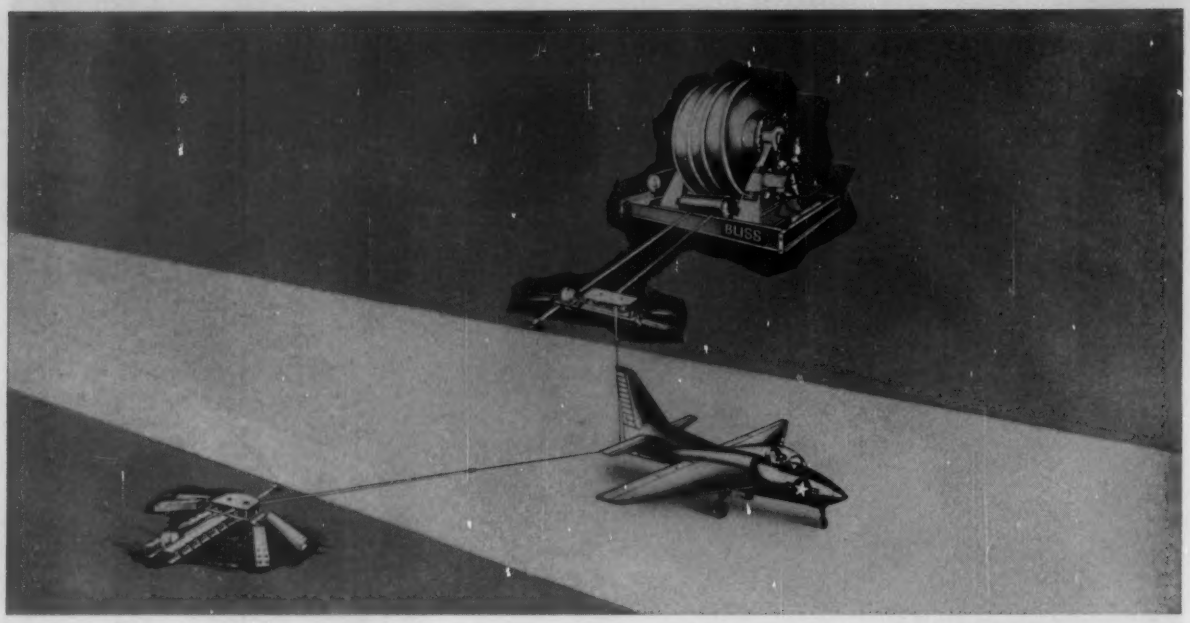
Nylon Tape Snags Runaway Jet



Emergency overrun barriers, developed by E. W. Bliss Co., Canton, Ohio, will save Air Force jets that can't stop themselves (because of brake failure, icy runways, etc.). They'll stop landing aircraft within a given "safety distance" without imposing stresses severe enough to injure the pilot. The arresting unit consists of a braking engine and two reels of light nylon tape. The tapes pass over pulleys at each side of the runway and are attached to an engagement cable. When the cable picks up an airplane's tail hook, the tape unwinds and a braking force is automatically applied to resist rotation of the reels. The braking engine, which can absorb over 33,000 hp while the tapes play out, will stop any jet fighter traveling at 210 mph within 1000 ft. When not in use, the arresting unit remains at the ready (engaging position) indefinitely; after use, it can be reset in less than three minutes by an electric rewind system.

Notty—New Naval Prototype

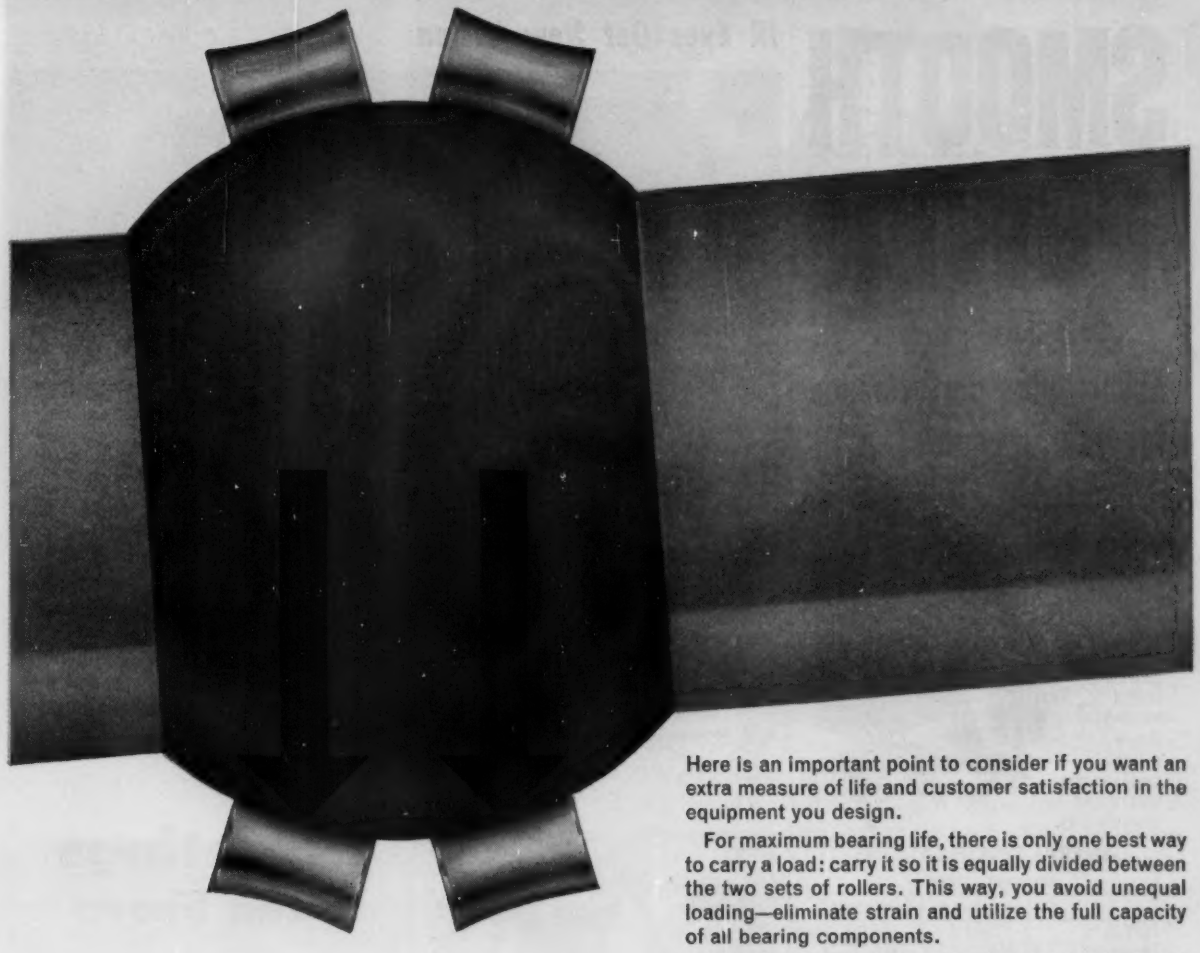
CHINA LAKE, CALIF.—A frolicsome lady porpoise may revolutionize design of underwater weapons. Notty (named after her base, Naval Ordnance Test Station) is being studied for many reasons: She swims at high speed with little drag; apparently delivers ten times as much horsepower per pound of muscle as other mammals (including humans); and has much better sonar equipment than any used by humans today.

Hydrodynamic studies of propulsion and drag are being made with plastic rings of known drag characteristics (Notty is trained to wear these rings and other test hardware). The porpoise swims through an area in which particles of neutral density have been suspended in the water. Colored dyes smeared on her skin aid flow-pattern studies (recorded by wide-angle cameras shooting at 400 frames per sec.)

One theory of the porpoise's speed is its use of a boundary-layer control to reduce drag. At the forward end of the animal, the skin is nearly bloodless. Toward the tail (where turbulence and drag normally build up) she has more blood vessels. Greater vascular circulation toward the aft end could produce smoother flow by increasing heat transfer and skin mobility. Heat-transfer studies, recorded by the Schlieren method, have pinpointed temperature changes as small as 0.005 F.

Acoustics is another area in which Notty is contributing. She navigates (even while blindfolded) by sending out and receiving sounds. Unlike sonar equipment, her sound output varies from 750 to 300,000 cps. Answers to how she generates this wide-band sonar could change concepts of underwater ordnance, sound detection, and anti-submarine warfare.

ELIMINATES MISALIGNMENT STRAIN



maintains

equal load distribution

despite

changing misalignment

Here is an important point to consider if you want an extra measure of life and customer satisfaction in the equipment you design.

For maximum bearing life, there is only one best way to carry a load: carry it so it is equally divided between the two sets of rollers. This way, you avoid unequal loading—eliminate strain and utilize the full capacity of all bearing components.

In the Shafer-Rex design, misalignment is eliminated before it reaches the rollers. So, despite shaft misalignment, the load in a Shafer-Rex is always aligned and equally divided on the rollers—providing extra protection against the strain of any punishment that might be dished out.

Original Shafer-Rex design is the reason. The inner race of a Shafer-Rex Self-Aligning Roller Bearing is a segment of a sphere; rollers are concave. With this design, the only part affected by misalignment is the inner race. Roller assemblies remain in the aligned position, carry the load equally to assure uniform loading through the center of each roller—a real lifesaver.

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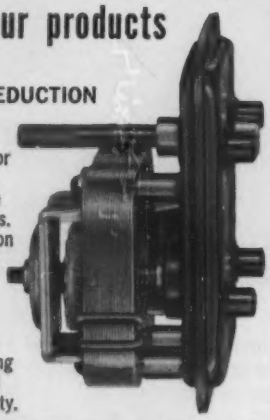

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MODEL 205		
	Intermittent	Continuous
SPEED	13 RPM	13 RPM
TORQUE	150 in./oz.	100 in./oz.
AMPS, No Load	2.5	1.25
WATTS, No Load	26	13
REVERSIBLE	No	No
CONDENSER	None	None
MODEL 308		
	Intermittent	Continuous
SPEED	13 RPM	13 RPM
TORQUE	200 in./oz.	75 in./oz.
AMPS, No Load	1.2	0.4
WATTS, No Load	25	7
REVERSIBLE	Yes	Yes
CONDENSER	60 MFD	25 MFD

Above data based on 24 volts — Intermittent Duty 3 minutes on and 5 off. Both models can also be supplied for 115 volts — 60 cycles.

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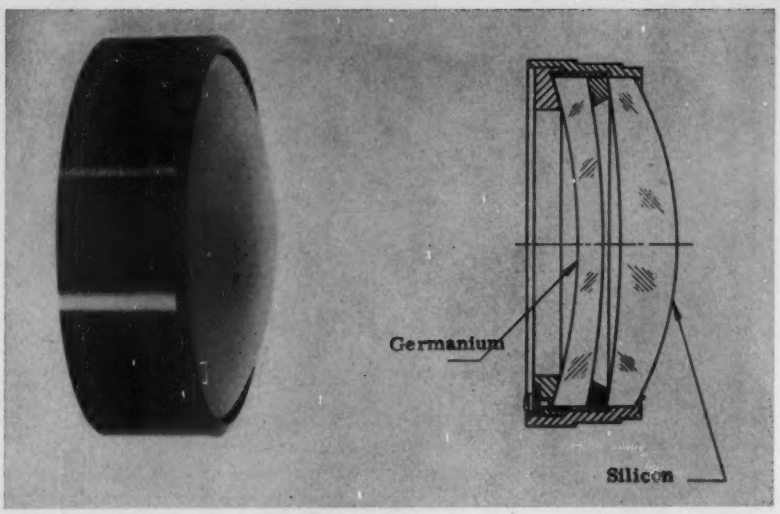
Circle 417 on Page 19

IR Eyes Get New Vision



Achromat lenses with high resolution in the 8-14 micron range of the infrared spectrum have been developed by Servo Corp. of America, Hicksville, N. Y. The new lenses complete coverage of the entire 1-14 mu spectrum. They are expected to pave the way for significant improvements in infrared equipment for both military and industrial applications. Missile-aiming devices and guidance systems, for example, will now be able to lock on colder targets and will receive stronger signals from targets they can hardly see today.

Polaris Blueprints Go To Sea on Film

Fast troubleshooting of the ballistic-missile system aboard each Polaris-carrying submarine requires, among other things, a complete file of engineering drawings. To make room for the thousands of blueprints involved, each has been compressed into a single frame of microfilm, mounted on a tabluating card, and filed in a single compact cabinet aboard the vessel. The sub also carries a push-button controlled reader-printer that supplies either a projected image or a permanent paper copy of the drawing. The Filmsort Aperture Cards and the Thermo-Fax Filmac reader are made by Minnesota Mining and Mfg. Co.

Meetings and Shows

Feb. 26-March 1—

First Pacific Electronic Trade Show to be held in the Great Western Exhibit Center, Los Angeles. Additional information can be obtained from PETS headquarters, 2216 South Hill St., Los Angeles 7, Calif.

March 5-9—

American Society of Mechanical Engineers. Gas Turbine Power Conference and Exhibit to be held at the Shoreham Hotel, Washington, D. C. Co-sponsor is the U. S. Dept. of Defense. Further information can be obtained from ASME Meetings Dept., 29 W. 39th St., New York 18, N. Y.

March 6-8—

American Management Association. Data Processing Conference and Exhibit to be held at the Statler Hilton Hotel, New York. Additional information can be obtained

(*Please turn to Page 40*)

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University surveys indicate:

STARTING SALARIES OF ENGINEERS ARE DECEPTIVELY HIGH

By James M. Jenks

TWO SEPARATE STUDIES of the salaries made by college graduates appear to contradict the commonly held belief that engineers today make out better financially than their classmates who major in non-technical subjects.

Both surveys were conducted by large universities. The first polled graduate engineers; the second, company executives. And both resulted in identical findings! That is, the average engineer today – despite a deceptively high starting salary–climbs fast but not far.

The need for technically trained men in recent years has exceeded the supply to such an extent that companies have been forced to bid for their services–to actually set-up "recruiting" offices on college campuses all over the country. Thus, starting salaries have gone up and up. But the income ceiling for these technically-trained men is lower than that for managerial personnel.

Despite the substantial head start engineers have, the differential in money earned over a ten-year period averages out at $7,000 more for the management man.

And from the tenth year on, the administrator's salary obviously outstrips that of the engineer by a wider and wider margin.

This, of course, is not to say that engineering students would be wise to shift to the study of business administration–or that working engineers face a bleak future. Quite to the contrary, the continuing growth of technology means that men with technical backgrounds are as ideally qualified for the highest rewards industry has to offer–*if they also have a knowledge of the underlying principles of business.*

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If you want to avoid the thorny barriers to success–if you're ambitious, determined to move up fast–send today for the Institute's 48-page descriptive booklet, "Forging Ahead in Business".

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There's no charge for "Forging Ahead in Business." And no obligation . . . other than the obligation to read it thoughtfully, and decide for yourself whether the training it describes is meant for you. To obtain your complimentary copy, simply fill out and return the coupon. It will be mailed to you promptly.

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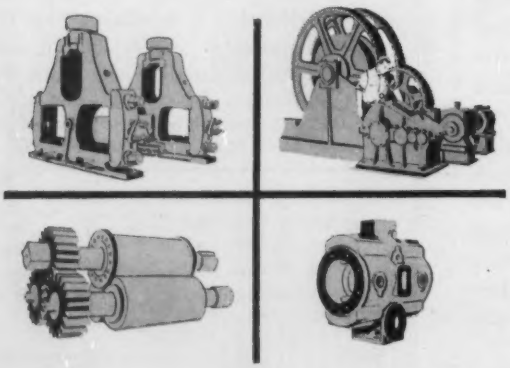
Chances are that you have us in mind as specialists in marine components and sugar machinery. It's a fact that our reputation was built on serving these fields, and we continue to do a large volume in them. What we would like to tell you is that we've expanded our facilities over the years to the point of extreme capability in electric furnace steel castings of medium and high carbon content, semi-steels in our iron foundry, and aluminum, monel and the various alloys of brass and bronze in our non-ferrous foundry. Our machine shop is equipped with some of the largest and most diversified tools in the South—rounding out our complete foundry facilities.

Service Foundry would like to work for you. Your inquiry will bring a prompt, definite reply.



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(*Continued from Page 36*)

from AMA headquarters, 1515 Broadway, New York 36, N. Y.

March 8-10—

Instrument Society of America. Annual Conference on Instrumentation for the Iron and Steel Industry to be held at the Roosevelt Hotel, Pittsburgh. Further information can be obtained from Richard R. Webster, Jones & Laughlin Steel Corp., Research Laboratory, 900 Agnew Ave., Pittsburgh 30, Pa.

March 11-14—

Steel Founders' Society of America. Annual Meeting to be held at the Drake Hotel, Chicago. Further information is available from society headquarters, 606 Terminal Tower, Cleveland 13, Ohio.

March 12-16—

American Society of Mechanical Engineers. Aviation Conference to be held at the Statler Hilton Hotel, Los Angeles. Additional information is available from ASME Meetings Dept., 29 W. 39th St., New York 18, N. Y.

March 13-17—

National Association of Corrosion Engineers. Annual Conference to be held at the Statler Hotel, Buffalo. Additional information can be obtained from NACE headquarters, 1016 M & M Bldg., Houston 2, Tex.

March 13-17—

Society of Automotive Engineers Inc. National Automobile and Production Meetings to be held at the Sheraton - Cadillac Hotel, Detroit. Further information can be obtained from SAE headquarters, 485 Lexington Ave., New York 17, N. Y.

March 16-17—

American Society of Mechanical Engineers. Textile Engineering Conference to be held at Clemson College, Clemson, S. C. Additional information can be obtained from ASME Meetings Dept., 29 W. 39th St., New York 18, N. Y.

March 20-23—

Institute of Radio Engineers. International Convention to be held

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at the Coliseum and the Waldorf-Astoria Hotel, New York. Additional information is available from IRE, 1 E. 79th St., New York 21, N. Y.

March 20-24—

American Society for Metals. Thirteenth Western Metal Exposition & Congress to be held at the Pan Pacific Auditorium, Los Angeles. Additional information can be obtained from ASM, Metals Park, Novelty, Ohio.

March 21-23—

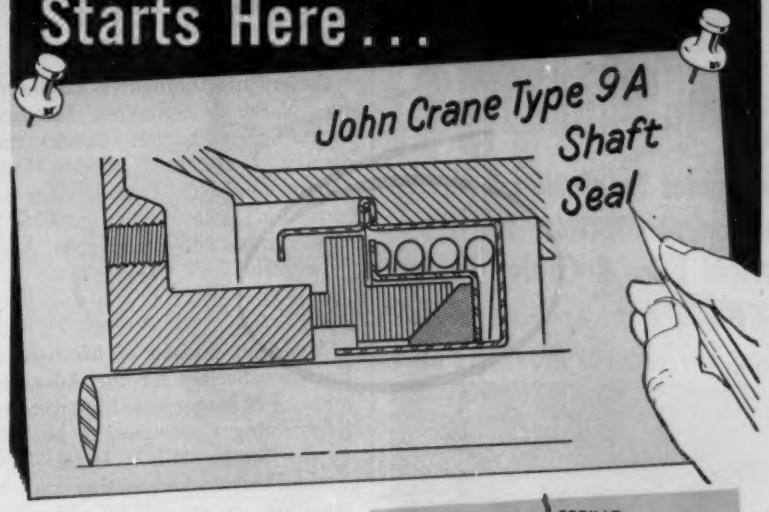
American Power Conference to be held at the Sherman Hotel, Chicago. Sponsors are nine engineering societies, including American Society of Mechanical Engineers, National Association of Power Engineers, American Institute of Electrical Engineers, American Society of Civil Engineers, and American Society of Heating, Refrigeration, and Air Conditioning Engineers; Illinois Institute of Technology and 13 other universities. Additional information can be obtained from R. A. Budenholzer, Illinois Institute of Technology, 35 W. 33rd St., Chicago 16, Ill.

April 4-6—

National Microfilm Association. Tenth Annual Meeting and Convention to be held at the Sherman Hotel, Chicago. Additional information can be obtained from the

"A rough sketch is all we need, just as long as it looks like a finished drawing."

Sealing Corrosive Liquids Starts Here...

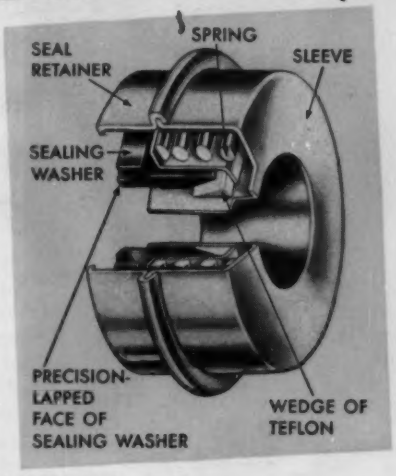


This cartridge-type shaft seal designed for the production line is engineered for:

(1) positive sealing of many industrial chemicals and solvents (note the Teflon* sealing wedge);

(2) leakproof handling of inflammables and toxics;

(3) operation over a wide temperature range from −120° to +500°F., pressures to 150 psi.



It offers the Original Equipment Manufacturers these important advantages:

(1) low unit cost through mass production;

(2) fast, one-piece installation through cartridge construction;

(3) equal efficiency on both low or high speed applications, because seal does not rotate with shaft.

The 9A Shaft Seal can be of stainless steel, monel, brass or other materials adapted to stamping and forming—depending on the service requirement.

Get full details. Request Bulletin S-205-3 from Crane Packing Co., 6425 Oakton Street, Morton Grove, Illinois *(Chicago Suburb).*

In Canada: Crane Packing Co., Ltd., Hamilton, Ont.

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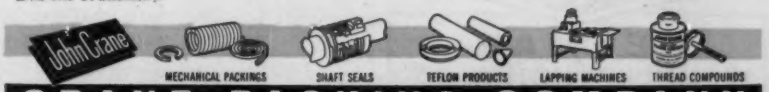

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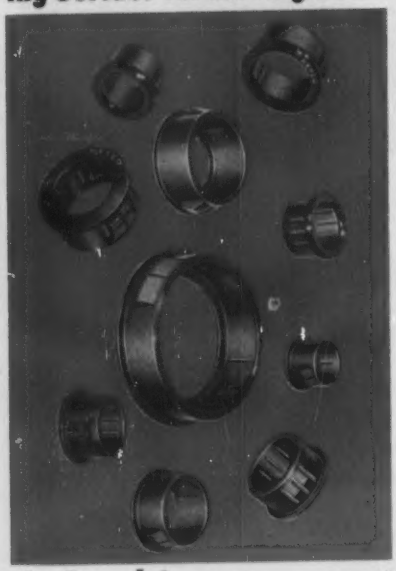
Circle 420 on Page 19

NYLON
Snap Bushings
Provide: Insulation & Mechanical protection for Electrical Wire & Cable, Tubing & Hose, Rope & Cable; Bearing Surface for Moving Parts



A Bushing to meet your requirements
Finger pressure snaps and locks bushing into panels of varying thickness up to ⅛"

- Withstands 35 lb. pushback tests!
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Circle 421 on Page 19

association's executive secretary, Vernon D. Tate, P. O. Box 386, Annapolis, Md.

April 4-7—

Society of Automotive Engineers Inc. National Aeronautic Meeting, including production forum and display, to be held at the Hotel Commodore, New York. Further information is available from SAE headquarters, 485 Lexington Ave., New York 17, N. Y.

April 6-7—

American Society of Mechanical Engineers-Society for the Advancement of Management. Management Engineering Conference to be held at the Statler Hilton Hotel, New York. Further information can be obtained from ASME Meetings Dept., 29 W. 39th St., New York 18, N. Y.

April 9-13—

American Society of Mechanical Engineers. Oil and Gas Power Conference and Exhibit to be held at the Jung Hotel, New Orleans. Additional information is available from ASME Meetings Dept., 29 W. 39th St., New York 18, N. Y.

April 10-21—

American Welding Society. 42nd Annual Convention and Welding Exposition to be held at the Coliseum, New York. AWS will also act as host to the International Institute of Welding, which meets at the Sheraton-Atlantic Hotel. Technical meetings of AWS will be held at the Commodore Hotel as well as the Coliseum. Additional information is available from society headquarters, 33 W. 39th St., New York 18, N. Y.

April 17-19—

Fifth Conference on Manufacturing Automation, cosponsored by Purdue University and Manufacturing Engineering Council and *Automation* magazine, to be held at Purdue University, Lafayette, Ind. Further information is available from K. E. Glancy, Div. of Adult Education, Purdue University, or *Automation*, Penton Bldg., Cleveland 13, Ohio.

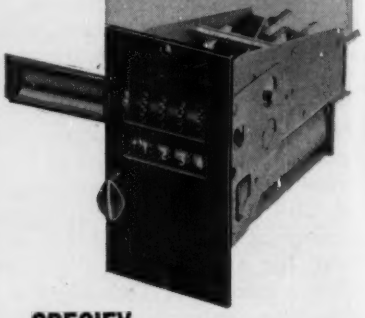
April 17-21—

Business Equipment Exposition to

Take advantage of these features:

- Size
- Speed
- Capacity
- Cost

and accuracy



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Available with remote electric or manual reset.

This precision instrument has the 100% accuracy feature typical of digital equipment. The in-line presentation, rather than dials, makes for substantially easier digital readouts. It is truly a sophisticated control in a compact package. Power requirement is low. And, you'll also be amazed at the low price.

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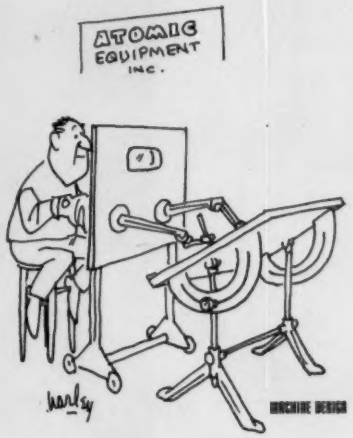
Circle 422 on Page 19

be held in the Coliseum, New York. Sponsor is the Office Equipment Manufacturers Institute. Further information is available from OEMI, 777 14th St. N.W., Washington 5, D. C.

April 18-20—

New England Electrical Trade Show to be held in the Commonwealth Armory, Boston. Sponsor is the Electrical Manufacturers Representatives Club of New England. Additional information can be obtained from Charles A. Stone, 45 Morrissey Blvd., Boston 25, Mass.



April 20-21—

Society of the Plastics Industry Inc. Annual Western Section Conference to be held at the Hotel del Coronado, Coronado, Calif. Further information can be obtained from SPI headquarters, 250 Park Ave., New York 17, N. Y.

April 23-26—

American Society of Mechanical Engineers. Metals Engineering Conference to be held at the Penn Sheraton Hotel, Pittsburgh. Further information is available from ASME Meetings Dept., 29 W. 39th St., New York 18, N. Y.

May 8-12—

American Foundrymen's Society. Castings Congress and Exposition to be held at Brooks Hall and the Civic Auditorium, San Francisco. Further information can be obtained

(*Please turn to Page 46*)

Design Uniform lift into equipment with DUFF-NORTON WORM GEAR JACKS

Many designers find a ready answer to precise control of linear motion in machinery or equipment with built-in Duff-Norton Worm Gear Jacks.

They are used singly, in tandem and in multiple jacking arrangements to position loads weighing from a few hundred pounds to as much as several hundred tons.

When connected in tandem or groups of four, six or more, these jacks always raise or lower in exact unison regardless of load distribution. They are also used for application of pressure, to push or pull and as linear actuators.

Duff-Norton Worm Gear Jacks are self-locking and will hold heavy loads in position indefinitely without any creep. Since there is no fluid or air to leak, the action is always positive and maintenance is no problem.

These jacks are available in eight standard models with capacities ranging from 2 to 100 tons and with standard raises from 6 to 24 inches. Special raises can also be furnished.

To learn more about how Duff-Norton Worm Gear Jacks may be used in your equipment, send for the bulletin which shows engineering drawings of jacks, Duff-Norton Mitre Gear Boxes and typical applications. Ask for **AD-66av.**

DUFF-NORTON COMPANY

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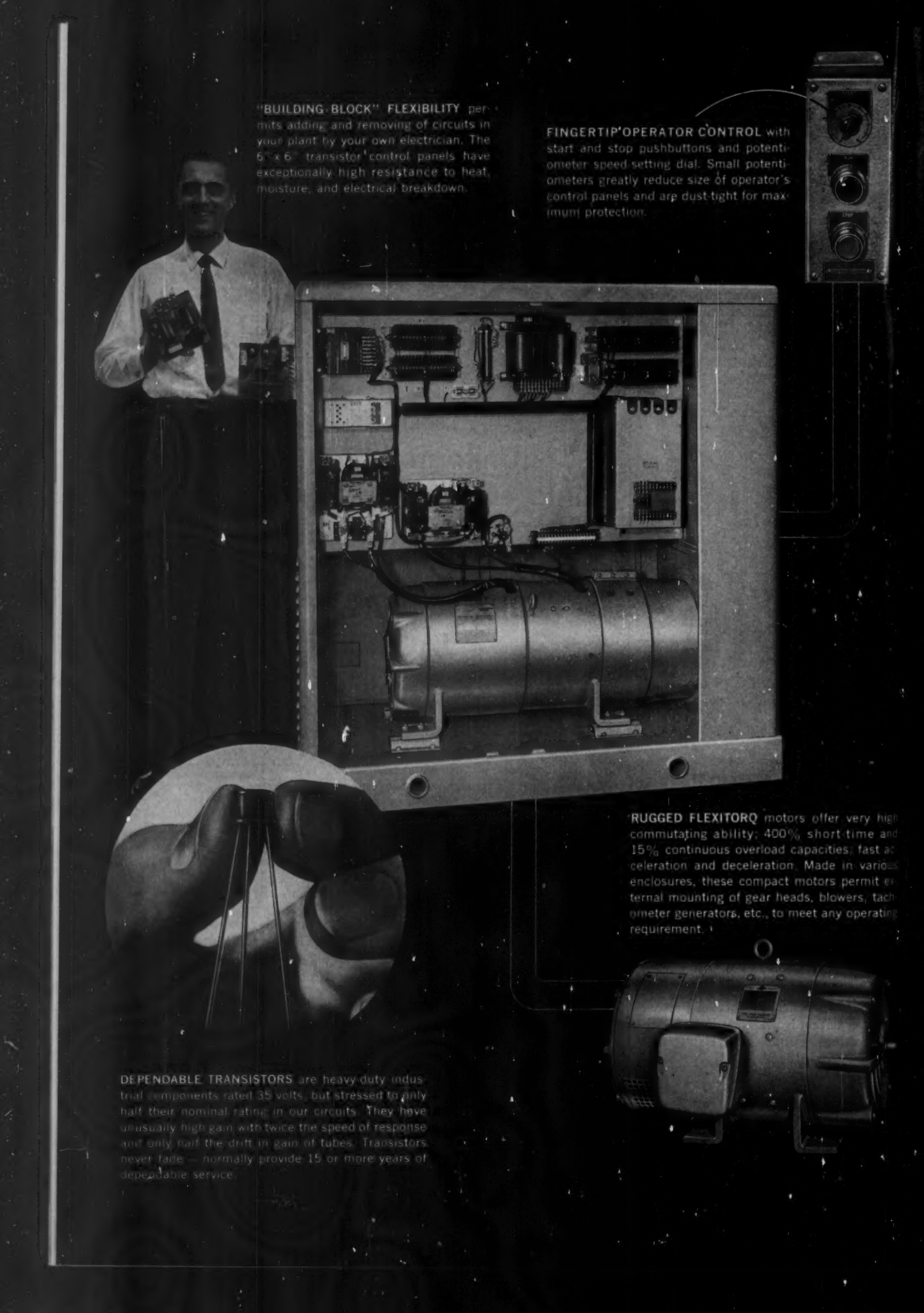

"BUILDING BLOCK" FLEXIBILITY permits adding and removing of circuits in your plant by your own electrician. The 6" x 6" transistor control panels have exceptionally high resistance to heat, moisture, and electrical breakdown.

FINGERTIP OPERATOR CONTROL with start and stop pushbuttons and potentiometer speed setting dial. Small potentiometers greatly reduce size of operator's control panels and are dust-tight for maximum protection.

RUGGED FLEXITORQ motors offer very high commutating ability; 400% short-time and 15% continuous overload capacities; fast acceleration and deceleration. Made in various enclosures, these compact motors permit external mounting of gear heads, blowers, tachometer generators, etc., to meet any operating requirement.

DEPENDABLE TRANSISTORS are heavy duty industrial components rated 35 volts, but stressed to only half their nominal rating in our circuits. They have unusually high gain with twice the speed of response and only half the drift in gain of tubes. Transistors never fade — normally provide 15 or more years of dependable service.

Another NEW product from Louis Allis

It's ideal for single-motor and synchronized multi-motor drives for:

- Extruders
- Wire-drawing machinery
- Machine tools
- Conveyors
- Calenders
- Paper machinery
- Textile machinery
- Printing presses
- Test stands
- Adjustable frequency power supplies

and many other applications

The New LOUIS ALLIS Select-A-Spede® Drive —First with field-proved All-Transistor Control

a high-gain, high-performance d-c drive with unmatched flexibility and low upkeep

Here's a superior adjustable speed drive with simplified transistor-magnetic amplifier control. It's the easiest drive to set up and operate. A twist of the dial gives you stepless speed adjustment from zero to full speed in either direction. Each adjustment is independent, thus sparing you the need for compensating adjustments of inter-related settings. You get more consistent day to day operation because transistors — *unlike tubes* — are highly dependable.

The new Select-A-Spede defies obsolescence. To add functions, such as current limit, to your basic drive, you simply have your electrician install the "current limit" transistor circuit panel. These "building-block" panels allow you to add any of the 13 control circuits that changing conditions call for — and they are immediately available from Louis Allis stock. Thus a rebuilding or adaptation job that, on former equipment, cost thousands of dollars — excluding down-time — can now be done at a fraction of the cost and time *right in your own plant!*

Transistor control practically eliminates upkeep and down-time. High quality transistors, field proven in missiles and other advanced electronic equipment, assure you of a high degree of dependability with a life expectancy of 15 or more years. Printed low-voltage transistor circuits are virtually trouble-free and can be quickly and easily replaced from low-cost stock.

Further savings are provided by the new Louis Allis Flexitorq® drive motors through vastly improved commutation, low brush wear, and their ability to safely withstand momentary overloads of 400% of normal horsepower rating.

If you want superior speed regulation on your drive, check the new Louis Allis Select-A-Spede with *all-transistor* control. Sizes from 5 to 400 hp—in a wide range of enclosures and speed ranges up to 20:1. Contact any one of the 60 Louis Allis District Offices for information and application assistance. Or write for bulletin 2001 to The Louis Allis Co., 459 E. Stewart St., Milwaukee 1, Wisconsin.

MANUFACTURER OF ELECTRIC MOTORS AND ADJUSTABLE SPEED DRIVES

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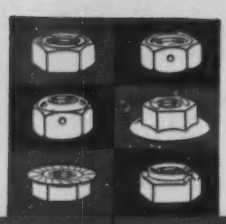
SA-2001

One  of these
CAN IMPROVE YOUR PRODUCT...

SIX GREAT
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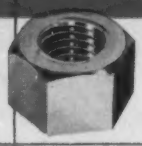
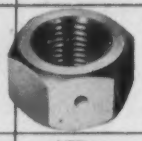
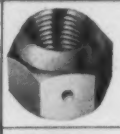
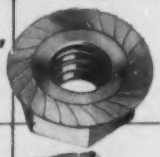
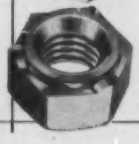
LOCK NUTS

MF **UNI-TORQUE**		A free starter with lock at the top. Withstands severe vibrations. Cuts assembly time.
MF **TWO-WAY**		The Lock's in the center of nut. Can be applied from either end. Permits bolt end to be flush with, or below, top of nut.
MF OPEN END **CAP NUT**		Has two-way center-of-nut lock. Used on furniture, appliances, toys, lawn mowers, tools, etc.
MF UNI-TORQUE **FLANGE NUT**		Combination lock nut and washer. Use on oversized holes; where extra bearing surface is needed.
MF **"WHIZ-LOCK"** FLANGE NUT		This one spins on. Serrations take a firm grip on work. Break loose torque higher than seated torque.
MF PILOT TYPE **WELD NUT**		You can have it with or without lock. Simplifies assemblies by means of self-locating pilot.

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MF LOCK NUTS

MacLean-Fogg Lock Nut Company
5535 N. WOLCOTT AVENUE
CHICAGO 40, ILLINOIS

WRITE OR CALL FOR ENGINEERING HELP ON FASTENING

(*Continued from Page 43*)

from AFS headquarters, Golf and Wolf Roads, Des Plaines, Ill.

May 8-12—
National Industrial Production Show of Canada to be held at the Industry and Coliseum buildings, Canadian National Exhibition Park, Toronto. The Canadian section of the American Society of Mechanical Engineers is among the sponsors. Additional information on the show is available from E. M. Wilcox Ltd., 19 Melinda St., Toronto, Canada.

Short Courses and Symposia

March 20-31—
Industrial Packaging Short Course to be held at Purdue University. Additional information is available from Mark E. Ocker, Conference Co-ordinator, Div. of Adult Education, Memorial Center, Purdue University, Lafayette, Ind.

March 27-28—
Production Institute, sponsored by the American Society of Tool and Manufacturing Engineers, to be held at the University of Wichita. Theme is "New Frontiers in Producibility," and subjects include aluminum castings, metal bonding, research and development costs, numerical control, and brazing honeycomb sections. Further information can be obtained from Prof. B. M. Aldrich, Co-ordinator, University of Wichita, Wichita, Kans.

March 27-31—
Fourth Symposium on Temperature—Its Measurement and Control in Science and Industry to be held at Veterans Memorial Hall and the Deshler-Hilton Hotel, Columbus, Ohio. Sponsors are Instrument Society of America, American Institute of Physics, and National Bureau of Standards. Further information is available from ISA, 313 Sixth Ave., Pittsburgh 22, Pa.

March 28—
17th Annual Quality Control Clinic to be held at the University of Rochester, Rochester, N. Y.

Sponsor is the Rochester Society for Quality Control. Further information can be obtained from Albert D. Rickmers, Associate Professor, College of Graphic Arts and Photography, School of Photography, Rochester Institute of Technology, 65 Plymouth Ave. South, Rochester 8, N. Y.

March 28-29—

Symposium on Nucleonics in Flight to be held at the Statler-Hilton Hotel, Dallas, Texas. Symposium will consider nuclear aspects of atmospheric and space systems for manned and/or unmanned space travel. Further information is available from Eldred L. Burkhard, Chairman, North Texas Section, American Nuclear Society, Convair Div., Fort Worth, Texas.

April 17-19—

Seventh National Symposium on Instrumental Methods of Analysis, to be held at the Shamrock-Hilton Hotel, Houston. Sponsor is the Instrument Society of America; additional information is available from Meetings Services Dept., ISA, 313 Sixth Ave., Pittsburgh 22, Pa.

April 18-19—

Process Planning-Operations Research Seminar to be held at the Statler Hilton Hotel, Cleveland, under the sponsorship of the American Society of Tool and Manufacturing Engineers. Further information is available from ASTME headquarters, 10700 Puritan Ave., Detroit 38, Mich.

April 30-May 4—

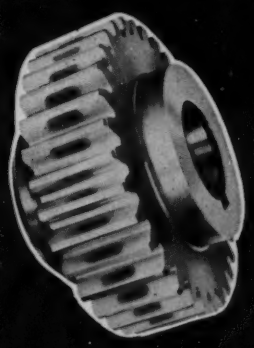
Aero-Space Instrumentation Symposium, sponsored by Instrument Society of America, to be held at the Adolphus Hotel, Dallas. Further information is available from W. J. Gabriel, Group Engineer, Convair Div., General Dynamics Corp., Ft. Worth, Texas.

May 8-9—

Lubrication Symposium, sponsored by American Society of Mechanical Engineers, to be held at the Deauville, Miami Beach, Fla. Additional information is available from ASME Meetings Dept., 29 West 39th St., New York 18, N. Y.

Give your machines the advantages of

SELF-ALIGNING GEARS!



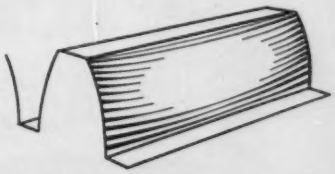
Sier-Bath

CROWN-GROUND

CASE-HARDENED SPUR and HELICAL GEARS

Similar in function to Self-Aligning Bearings, *Sier-Bath's* CROWN-GROUND GEARS Eliminate the damaging effects of

— MISALIGNMENT
— SHAFT DEFLECTION
— TOOTH DISTORTION



What is Crown-Grinding? As perfected by Sier-Bath gear specialists, the horizontal section and vertical profile of the gear tooth face is modified by Grinding *after Hardening* so that the CROWN-GROUND teeth are thinner at the ends than the center and the involute profile is simultaneously relieved in accordance with the requirements of each particular application. Tooth action is concentrated over the crowned central area where strength is greatest. Destructive "End Bearing" is eliminated while extreme quietness and a smoothly uniform tooth action are maintained even under severest misalignment, deflection, loads and speeds.

Because Sier-Bath crown-grinds *after hardening,* heat-treatment distortions are entirely eliminated. Hence the "Crown" can be attained in materials of 38 Rc and harder while simultaneously maintaining required tooth accuracies. Install Sier-Bath Crown-Ground spur and helical gears in your machinery for greater design latitude—greater productiveness and longer life for your equipment.

COST NO MORE!

IF YOU ARE USING GROUND TOOTH GEARS, these Sier-Bath Crown-Ground gears cost the same as, and often less than, commercially-made ground tooth gears.

Send details or print of your application—or request a Sier-Bath gear engineer to explain the vast improvements possible in your machines by using Crown-Ground case-hardened gears. Write on your Company letterhead for literature regarding Sier-Bath's "Gears of Tomorrow".

Sier-Bath PRECISION GEARS

Also manufacturers of Rotary Pumps and Flexible Gear Couplings

Founded 1905 Members A.G.M.A.

Sier-Bath GEAR & PUMP CO., Inc.

9237 Hudson Blvd., North Bergen, N. J.

NEW SMALL MAGNETIC STARTER COSTS LESS, SAVES SPACE ON LOW-HORSEPOWER JOBS!

CLASS 8536

Square D NEMA Size 00 Starter Rated ¾ to 2 Hp for 3-Phase Service

• You no longer need to buy more starter capacity than you can use for low-horsepower jobs! This new Square D Size 00 starter is compact, easy to install, simple to use and maintain—and it costs 18% less than the Size 0 starter you formerly had to specify to get the advantages of magnetic control! With no sacrifice in quality, this new starter provides: straight-through wiring—pressure-type terminals—1-piece overload relays for complete motor protection—pushbutton or selector switch optional in the cover. Also available without overload relays.

GET THE COMPLETE STORY! Write for Bulletin SM-297. Square D Company, 4041 North Richards St., Milwaukee 12, Wisconsin.

New starter is available either open or in NEMA Type 1 enclosure. Enclosure shown with selector switch in cover.

SQUARE D COMPANY

wherever electricity is distributed and controlled

They make piston pins faster for less money with USS National Seamless Mechanical Tubing

It takes plenty of machine time to drill and machine the holes in 6,500,000 piston pins a year. That's what one major auto company* had to do . . . *until* the switch to USS National Seamless Steel Mechanical Tubing. By eliminating the need to drill holes in the bar stock, the company got rid of six chuckers formerly used for drilling, saved time as well as the power they consumed and the space they occupied. ☐ USS National Seamless Tubing has dimensional accuracy. It has no hard or soft spots. It's made by people who know more about seamless tubing than any other manufacturer in the world. You can choose from a complete range of sizes and steel grades. Find out how USS National Seamless Mechanical Tubing can be most effectively applied to your designs. Contact your nearest National Tube Distributor soon.

USS and National are registered trademarks

**Name supplied on request*

National Tube Division of United States Steel

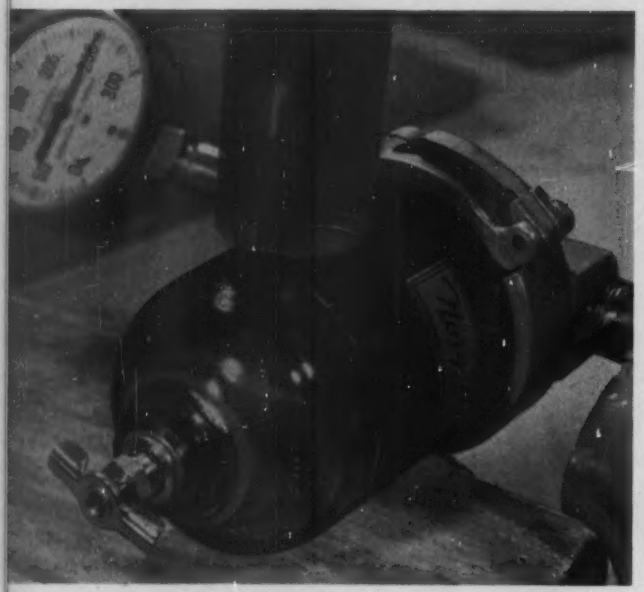
Columbia-Geneva Steel Division, San Francisco, Pacific Coast Distributors
United States Steel Supply Division
United States Steel Export Company, New York

This mark tells you a product is made of modern, dependable Steel.

Circle 428 on Page 19

NEW NORGREN TRANSPARENT BOWL WITHSTANDS RIPPING IMPACT OF HOLLOW NOSE BULLET

Norgren "Safety-Green" bowl doesn't shatter... yet is fully transparent



Heavy steel bar dropped endwise from 12 ft. height merely scuffed surface of bowl carrying over 200 psi internal pressure.

Bowls for compressed-air-line filters and lubricators should be transparent to permit quick visual inspection. However, in the past, unusual or special applications often required the use of bowl guards or wire reinforcements ... sacrificing the advantage of transparency.

Now ... from Norgren ... you get a fully transparent, yet super-tough, impact-resistant bowl that won't shatter, craze or break—designed for even the most severe service. As these photos dramatically portray, the new Norgren bowls are completely transparent and are able to withstand conditions far more exacting than ever encountered in ordinary use. Non-shattering, unbreakable bowls mean reduced replacement cost, less air-tool and equipment down-time, savings in maintenance and operating costs, greater employee safety.

These new green shatterproof bowls are now available for most Norgren air-line filters and lubricators—or may be obtained separately for replacement purposes from your local Norgren representative or distributor. Or, write for full information.

As a further test of toughness, the new Norgren bowl was placed in a heavy machine shop vise ...

then compressed almost flat. Even in this extreme position, the bowl did not break or even crack.

Turned and squeezed again back to its original shape, the bowl still showed no cracking. Except for vise marks almost good as new!

...WITH NO SHATTERING!

Unretouched high-speed photo by University of Denver Research Dept. shows new Norgren Safety-Green Bowl a split second after penetration by bullet. Initial pressure of 265 psi is being relieved through bullet hole.

Specify Norgren "Safety-Green" Bowls

Large photo shows bowl after test. Only damage to bowl is clean bullet hole with no cracking, crazing or shattering. Impact has broken gauge. This test clearly demonstrates extreme toughness of Norgren Safety-Green bowls.

FOUNDED IN 1926

. . . for complete information, write

C. A. NORGREN CO.

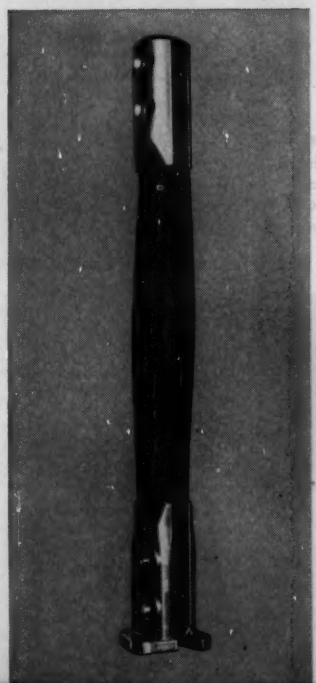
3442 SOUTH ELATI STREET ENGLEWOOD, COLORADO

Circle 429 on Page 19

3-DIMENSIONAL METALLURGICAL TEAMS:

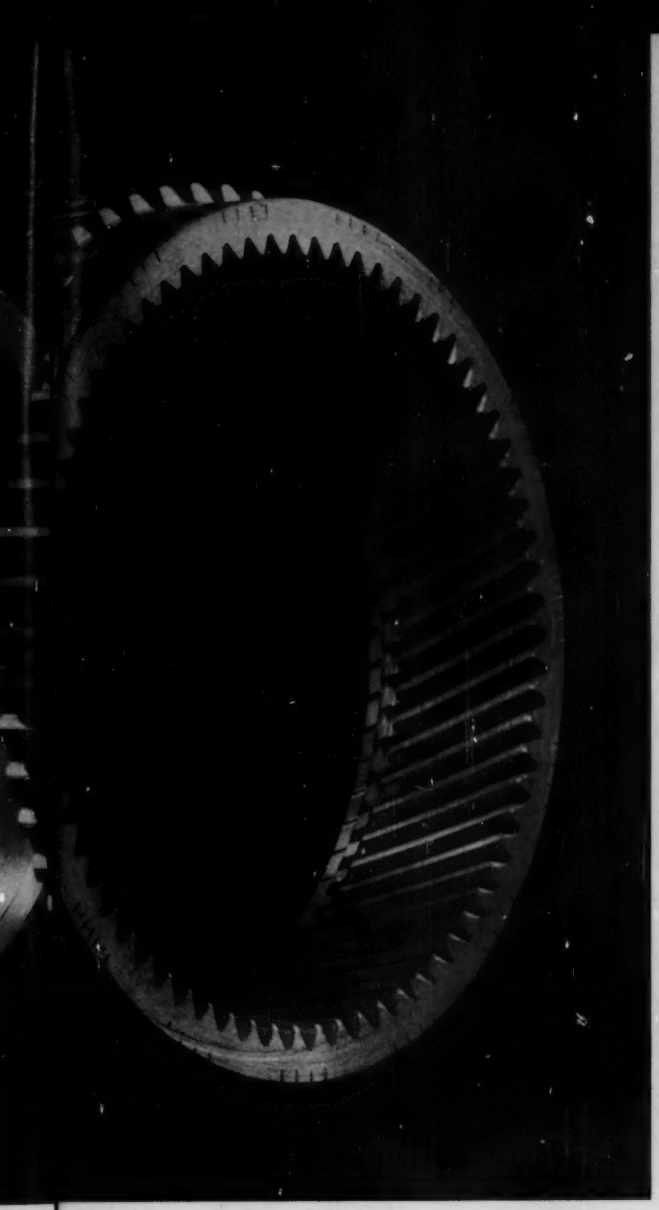
Republic's mill, field, and laboratory metallurgists and machining experts help you select and apply the metal best suited to requirements. Mail coupon for details on this confidential, obligation-free service.

Circle 601 on Page 19



KAMAN AIRCRAFT CORPORATION, Bloomfield, Connecticut, uses Republic Titanium in the rotor system of their HU2K "SEASPRITE" Helicopter. 1½″ x 18″ titanium (type RS140) strips are assembled in bundles of 88 and machined into retention straps capable of working through a torsion angle of ±13°. Each strap provides a minimum tensile strength of 155,000 psi.

Circle 602 on Page 19



MORE STRENGTH, MORE VALUE, MORE MILES

Why Republic Alloy Steel is specified for critical transmission components

One good example is the alloy steel planetary ring gear above. Produced by the Warner Gear Division of Borg-Warner Corporation, Muncie, Indiana, this part must withstand severe shock, strain, impact, and wear.

Republic Hot Rolled Alloy Steel, Type 4047, was selected to assure strength and toughness with the best possible degree of machinability. The alloy is forged, rough machined, broached, hobbed, and heat treated. Uniform response to heat treatment provides hard surfaces around tough cores, and assures maximum resistance to abrasion, friction, and wear.

Records prove that the uniformity of this alloy steel has reduced reject rate and scrap loss. This, along with the high machinability, is holding unit cost of the planetary ring gear to an absolute minimum.

Our metallurgists will help you select and apply the most economical alloy steel capable of meeting your requirements. For information, contact your nearest Republic sales office or mail the coupon below. Please indicate if you would like a metallurgist to call.

Circle 603 on Page 19

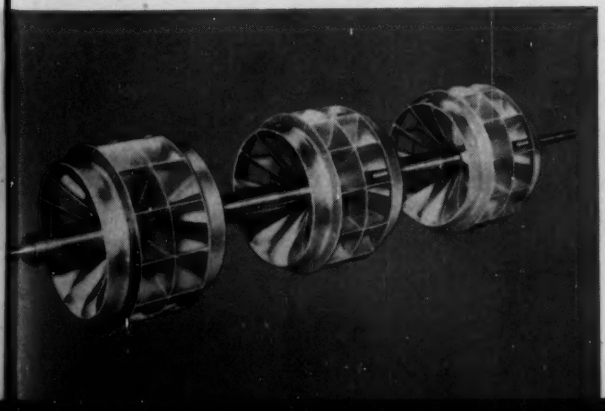
REPUBLIC STEEL

World's Widest Range of Standard Steels and Steel Products

Strong, Modern, Dependable

BUFFALO FORGE COMPANY uses Republic ELECTRUNITE® Mechanical Tubing in the production of rotor shafts that require exact balance to maintain high operating efficiency. Up to 94" in length, these shafts turn at 1110 rpm. Close tolerance concentricity of ELECTRUNITE meets requirements without costly machining. Available in carbon and stainless steel. Mail coupon for details.

Circle 604 on Page 19



REPUBLIC STEEL CORPORATION
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Please send more information on:
- ☐ Republic Alloy Steel
- ☐ ELECTRUNITE Mechanical Tubing
- ☐ Titanium

Have a metallurgist call:
- ☐ Republic Alloy Steel
- ☐ Titanium

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Company_____

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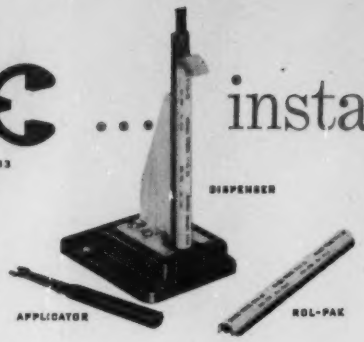
Truarc Rings ... installed with these Truarc tools

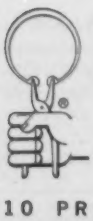


...enable Revere Camera Co. to speed assembly

...and improve servicing of its tape recorders.

Result: Revere now uses Truarc rings on all its quality recorders, cameras and projectors.

PRODUCTION PROPOSITION: Let a Truarc representative study your production line set-up soon. He can show you exactly how Truarc rings and assembly tools can help save time, money, and materials besides lowering the final assembled cost of your product. Call him and see. Catalog AT 10-58 shows the complete line of Truarc rings and assembly tools that can be used on your production line profitably. Write for it today. Your nearest **Authorized Truarc Distributor** is as close as your telephone. For immediate action, check your Classified Telephone Directory under: "Rings, Retaining." 0.2



WALDES TRUARC® RETAINING RINGS

WALDES KOHINOOR, INC., 47-16 Austel Place, Long Island City 1, N. Y.

9 OUT OF 10 PRODUCTS CAN BE IMPROVED WITH TRUARC RETAINING RINGS

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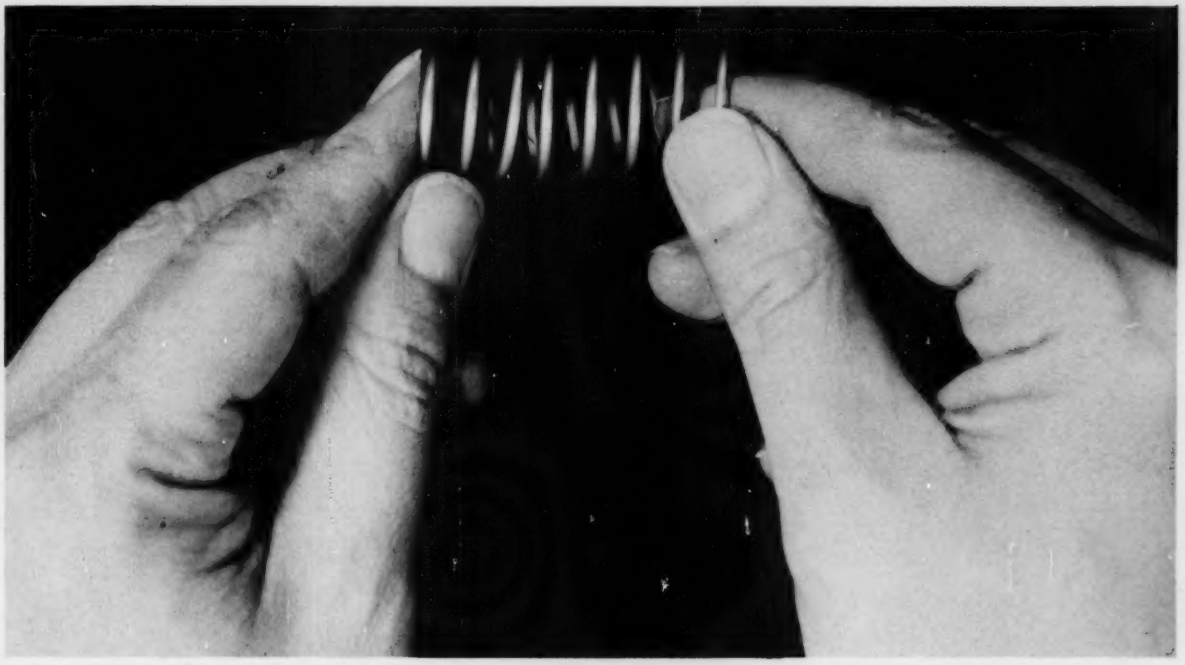
Circle 431 on Page 19

Circle 432 on Page 19→

N-S SPRING MATERIAL MAKES THE DIFFERENCE



MUSIC WIRE . . . STAINLESS . . . SUPERALLOY . . . HEAVY GALVANIZED . . . FLAT SPRING STEEL . . . *whatever your spring-material needs,* **NATIONAL-STANDARD** *has a complete line to give you one-source service. Many sizes are stocked for immediate delivery, others can be specially manufactured for 48-hour service, and all are produced with the quality and reliability of fifty-four years of experience.* **MUSIC SPRING WIRE:** *.002" to .250" diameter.* **STAINLESS STEEL SPRING WIRE:** *round—.0032" to .125" diameter; flat—.025" to .350" wide, .008" to .100" thick.* **HEAVY GALVANIZED SPRING WIRE:** *.012" to .060" diameter, 3-7% zinc by weight.* **SUPERALLOY SPRING WIRE:** *Inconel-X, NS-25 (L605), NS-A286, René 41, 17-7 PH, and others.* **FLAT SPRING STEEL:** *.001" to .065" thick, .015" to 6.5" wide tempered, .015" to 16" wide untempered.*

61-W01A

FOR COMPLETE TECHNICAL DATA ON NS QUALITY SPRING MATERIAL WRITE TO:

NATIONAL-STANDARD COMPANY
Niles, Michigan

NS SPECIAL WIRE WITHSTANDS 1000°F

Landing hot jets like the McDonnell Phantom II at high speeds, means brakes and brake components must be able to withstand extreme temperatures without failure.

A leading manufacturer of brakes for jet aircraft came to National-Standard for help in finding a spring wire that would have high stress-temperature stability up to 1000°F. National-Standard engineers recommended an austenitic superalloy material, NS-A286, recently developed for spring wire applications by National-Standard. Tests showed that NS-A286 met requirements better than any other available alloy, yet cost only half as much as the next best alloy.

SUPERALLOY PASSES TEST—When brakes on the Phantom II are released, the NS-A286 return springs under the brake discs must separate the stationary stator discs from the moving rotor discs. The brake discs build up heat to 1400°F, which is quickly absorbed by the return springs, raising spring temperatures to as much as 1000°F. NS-A286 is a precipitation hardening alloy exhibiting as little as half the relaxation loss at 1000°F as comparable alloys show at 850°F. NS-A286 springs must retain their strength at this heat to separate the brake discs and guard against brake drag during landings.

To test NS-A286, engineers simulated stress-temperature characteristics of three landing conditions.

TO BRAKE JETS

Heat builds up in the brakes in 30 seconds and remains for as long as 20 minutes. The springs must work in the heat against a high back pressure maintained in the aircraft hydraulic system. Springs must be operational for at least 45 normal landings, 5 high-speed, gross weight landings, and one aborted take-off stop, corresponding to stopping the plane just before it becomes airborne. Under all test conditions, NS-A286 met every rigid requirement.

EXPERIENCED ENGINEERING HELP of this kind, for jobs requiring high-quality wire, to meet special or unique applications, is available to you from National-Standard. Write for additional information to National-Standard Company, Niles, Michigan.

NS-A286 SUPERALLOY WIRE, produced by National-Standard, meets critical stress-temperature demands for coaxial return springs in brakes of F4H-1 Phantom II.

Manufacturer of Specialty Wire and Metal Products

NATIONAL-STANDARD COMPANY

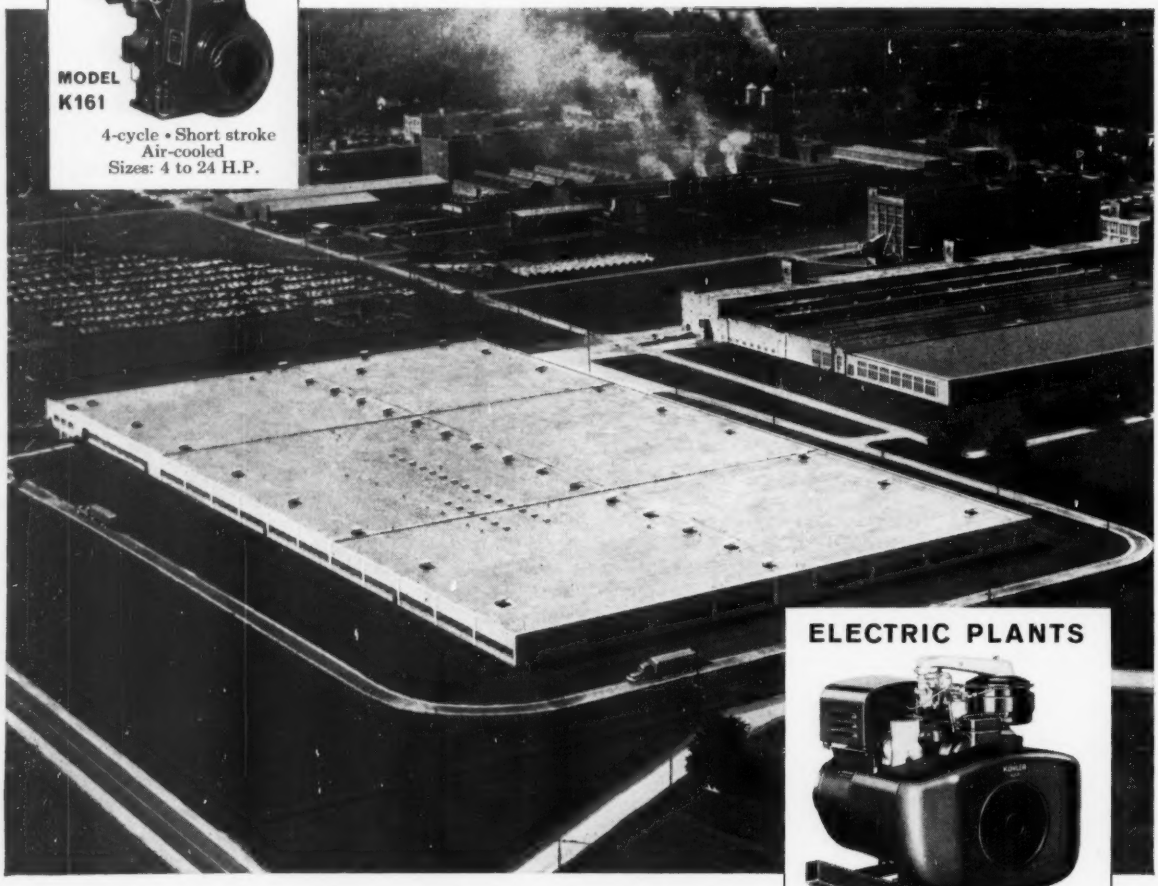
Niles, Michigan

ENGINES

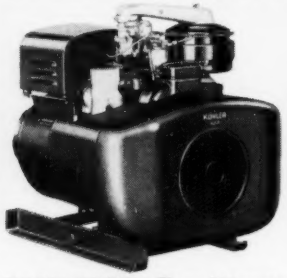
MODEL K161

4-cycle • Short stroke
Air-cooled
Sizes: 4 to 24 H.P.

NEW KOHLER ENGINE AND ELECTRIC PLANT BUILDING



ELECTRIC PLANTS



MODEL 5RM61 • Sizes: 500 watts to 115 KW, gasoline and diesel

Capacity to meet growing sales

Our customers' requirements will be met better than ever by the 12 acre new factory devoted entirely to the manufacture of engines and electric plants at Kohler, Wisconsin.

The building provides nearly three times the space formerly available, and allows for further expansion. Straight-line, one-floor production and newest equipment mean increased production, prompt deliveries.

Kohler engines, manufactured since 1920, are being increasingly specified for equipment used in agriculture, construction, industry and recreation. Kohler electric plants, known the world over for reliability, provide efficient electric power for sole supply, portable, automatic standby and marine uses.

Highest standards in meeting your service requirements are assured by service schools at the factory and in the field, where Kohler engineers train representatives of the nation-wide distributor and dealer organization.

The new factory is part of a continuing plan of expansion and diversification by Kohler Co.

Write for illustrated printed matter

KOHLER CO. *Established 1873* KOHLER, WIS.

KOHLER OF KOHLER

ENAMELED IRON AND VITREOUS CHINA PLUMBING FIXTURES • ALL-BRASS FITTINGS • ELECTRIC PLANTS • AIR-COOLED ENGINES • PRECISION CONTROLS

Gasket engineering

PRACTICAL TOLERANCES CAN CUT GASKET COSTS

Close tolerances in resilient gasket thickness are seldom necessary. Units with extremely close assembly tolerances can usually be sealed with compressible cork-and-rubber materials made to commercial standards.

Tolerances in gasket thickness do not become critical if the material chosen seals effectively over a wide range of compressions.

Armstrong cork-and-rubber compounds are typical of such materials. They will compress from 20% to 33% —depending on the amount of cork in the particular compound—without excessive sideflow.

The cork content of these materials makes them truly compressible. They actually decrease in volume under load. This makes them particularly valuable where the gasket is confined without relief. The absence of sideflow makes it easy to mate flanges.

Tolerances in the gauge of cork-and-rubber gaskets can be as wide as ±.015". This means that commercial tolerances for such materials are perfectly satisfactory for practically all applications.

Equally important—in some cases, more important—the compressibility of cork and rubber sometimes permits increases in the tolerances of the metal components, producing important savings in machining time.

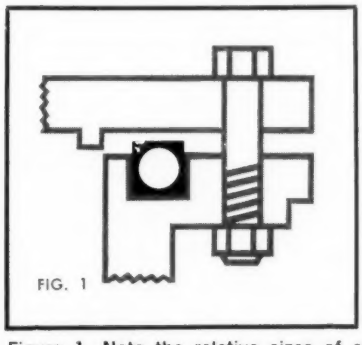


Figure 1. Note the relative sizes of a cork-and-rubber gasket and a comparable non-compressible molded ring. While the ring must be made to very close tolerances, cork-and-rubber's tolerance is not critical.

Figure 1 illustrates the relative sizes of a cork-and-rubber gasket and a comparable non-compressible molded ring. The resilient cork-and-rubber compound permits wide tolerance in its size. The molded ring, however, must be made to very close tolerances to allow perfect fit between the flanges.

Similarly, in figure 2, wide tolerance cork-and-rubber gaskets make an effective packing ring. Their true compressibility controls lateral flow and prevents build-up of radial pressure on the shaft.

When non-compressible rings were used on the flanged journal of the calender roll shown in figure 3, extremely close tolerances were required. Undersized rings leaked. Oversized rings prevented metal-to-metal contact between the flanges and caused misalignment. Both problems were solved with standard-tolerance cork-and-rubber rings, which fitted perfectly and sealed tightly.

There are fifteen different Armstrong cork-and-rubber materials available, including four sponged types. These compounds are made with nitrile-, styrene-, chloroprene-, or butyl-type synthetic rubber binders.

The chemical resistance of these compounds is comparable to that of the corresponding base polymers. Several Armstrong materials meet MIL-G-6183 and other specifications.

In density, Armstrong cork-and-rubbers range from soft, cork-like compounds to very firm compositions that are nearly as incompressible as straight rubber materials. All non-sponged compositions are impervious in their uncompressed state.

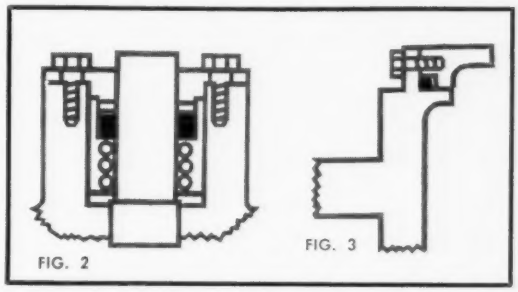


Figure 2. As a packing ring, cork-and-rubber does not build up excessive radial pressure on the shaft.

Figure 3. Cork-and-rubber gasket on flanged journal of calender roll.

We also offer special-purpose compounds based on silicone and fluorocarbon polymers for use at temperatures 100° F. to 150° F. above the limit for presently available standard cork-and-rubbers. These special compounds have compressibility in the range of 15% to 25% at 400 psi.

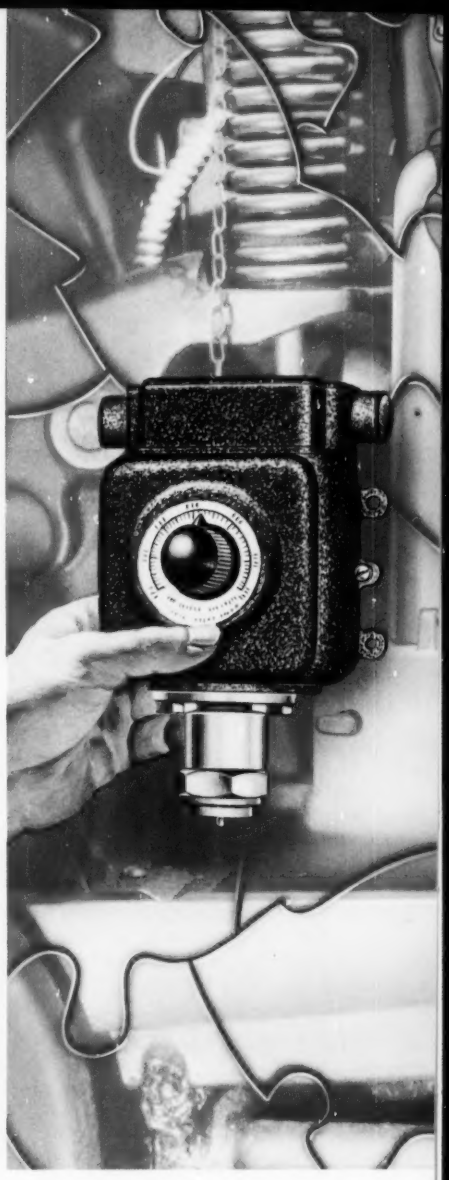
A catalog describing all Armstrong materials will be sent on request. Detailed information on the selection, design, and performance of resilient gasket materials is contained in the Armstrong Gasket Design Manual. Write for your free copy today. Address Armstrong Cork Company, 7102 Dean Street, Lancaster, Penna.

Armstrong GASKET MATERIALS

Please direct inquiries to advertiser, mentioning MACHINE DESIGN

Circle 434 on Page 19→

Partlow makes 25 different indicating control models, including the handsome, high-visibility MFS shown here.



Partlow non-indicating controls give maximum dependability at minimum cost.

A Perfect Fit for Any Temperature Control Application!

Partlow temperature controls today function in an almost infinite range of industrial processes . . . Economically. Accurately. *Precisely!*

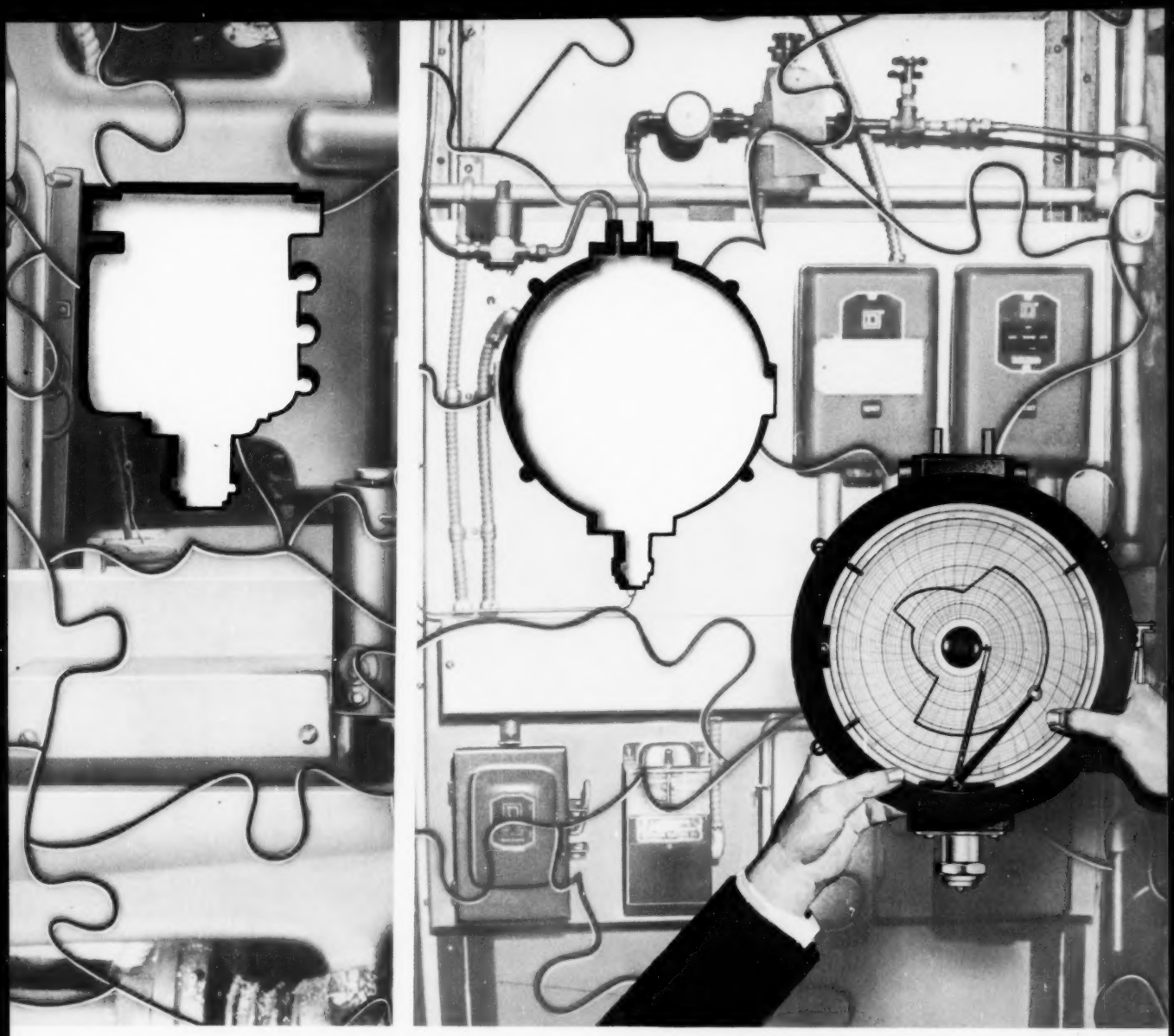
They can perform just as efficiently for *you*.

Partlow controls are actuated by the direct, positive power of mercury, require no mechanical or electronic amplification. Regardless of type, any Partlow you install will stand up to even extreme conditions of shock and vibration . . . without loss of accuracy or sensitivity.

And Partlow makes service headaches a thing of the past! All it takes to replace the Partlow thermal element is a wrench or screwdriver. No 'down time' necessary! The whole job can be done, right at the work site, in a matter of minutes.

If you need accurate, dependable temperature control anywhere within the −70° to 1100°F. range, you'll find a Partlow model to fit your requirements *exactly*.

Get full details without obligation. Fill out and mail the coupon now.



Versatile Partlow recording instruments keep rigid control of process temperatures, and prove it in writing.

Partlow makes the following types of controls and allied equipment for temperatures ranging from −70° F. to 1100° F.:

- **Electric**
- **Mechanical**
- **Pneumatic**
- **Indicating**
- **Non-Indicating**
- **Recording**
- **Explosion-Proof**
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- **Limit**
- **Program**
- **Multi-Switch**
- **Double Pen Recording**
- **Process Timers**
- **Safety Equipment**
- **Thermometers**
- **Control Accessories**

41 Partlow Sales and Service Offices in Principal Cities of the United States, and the World.

World Export: Ad Auriema Inc., 85 Broad Street, New York 4, N.Y., U.S.A.

PARTLOW

TEMPERATURE CONTROLS

THE PARTLOW CORPORATION

New Hartford, N.Y., Dept. B

Please send condensed Catalog of Partlow temperature controls and allied equipment for industrial heating and refrigeration.

Name and Title.....

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CUSTOM GEARS AND GEAR BOXES assure this kind of *dependability*. They are precision made, guaranteed to meet your specifications exactly!

Ask for this brochure—CINCINNATI custom gears are made in all types to 72″ diameter cut teeth, 39″ shaved teeth, 25″ ground teeth.

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THE CINCINNATI GEAR CO.

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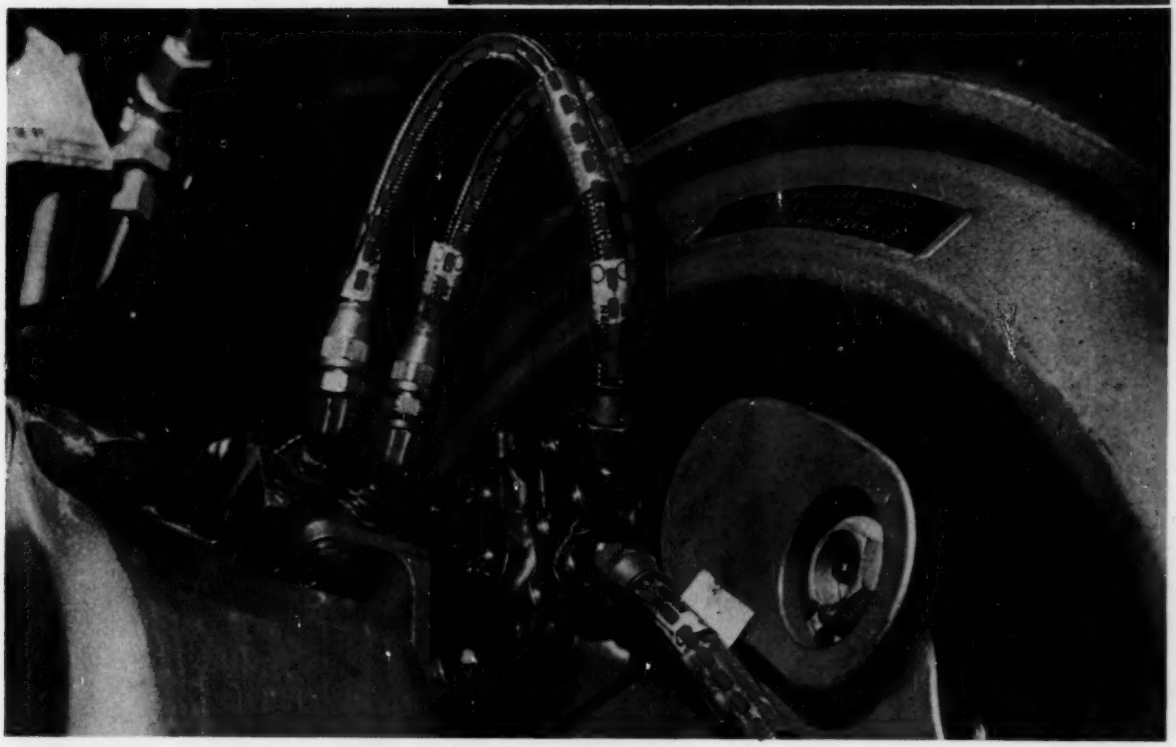
Custom Gear Makers Since 1907 GEARS, good gears only

DU PONT TEFLON®



Hose lined with TEFLON® solves problems of pressure, temperature, corrosion, limited space

CAN YOU AFFORD NOT TO USE TEFLON?

Constructions of hose lined with TEFLON are your logical and most economical choice whenever severe environmental conditions are encounted, AND whenever you want—

. . . functional reliability and greatly increased service life

. . . reduced costs of replacement, maintenance and downtime

. . . greater standardization with reduced inventories

. . . the competitive advantage of quality and dependability

If any of these considerations are important to your design, the choice of any other kind of hose might well be wasteful.

Hoses lined with Du Pont TEFLON TFE fluorocarbon resins are employed throughout a new commercial cargo plane to insure the utmost reliability under exacting service conditions. Shown above are hose lines to the hydraulic anti-skid brake system, operating at 1,750 psi and in the presence of corrosive fluids. In addition to these fluid power lines, other hoses lined with TEFLON handle oils and fuels at temperatures to 200°F. and pressures up to 3,000 psi.

In a wide variety of industrial designs, hose lined with TEFLON is providing complete resistance to virtually all chemicals encountered . . . exceptional durability under continuous flexing, including torque stress and vibration . . . and making possible space savings by the use of smaller outside-diameter hose.

New constructions include fiber reinforcements, elastomeric coverings, convoluted tubing and a variety of industrial couplings. For more details, consult your hose supplier, or write to: E. I. du Pont de Nemours & Co. (Inc.), Dept. MD-2-16, Room 2526T, Nemours Bldg., Wilmington 98, Del. **In Canada**: Du Pont of Canada Ltd., P. O. Box 660, Montreal, Que.

DU PONT TEFLON® FLUOROCARBON RESINS

TEFLON is Du Pont's registered trademark for its family of fluorocarbon resins, including TFE (tetrafluoroethylene) resins and FEP (fluorinated ethylene propylene) resins.

BETTER THINGS FOR BETTER LIVING . . THROUGH CHEMISTRY

WHEN YOUR "SPECS" READ HYATT YOU GET TRIPLE VERSATILITY

USE THE HYATT IMPROVED

1 MORE FLEXIBLE ASSEMBLY

Interchangeability of Hyatt separable bearing parts permits more flexible assembly. Any HYATT Metric Radial Series separable inner race, for a given piece number, can be assembled with any HYATT outer race and roller assembly of the same piece number.

Because of this interchangeability, it is practical to install separable HYATT inner races on shafts in one location, while the outer races and rollers are installed in housings at another location. When the sub-assemblies are brought together, the bearing parts will match perfectly. There is seldom need for selective assembly.

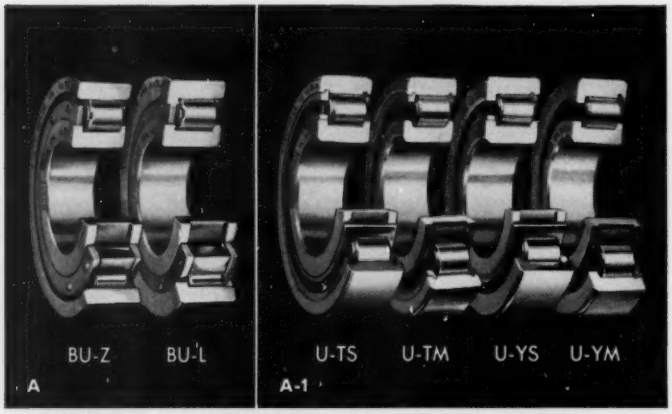
2 INCREASED SHAFT DIAMETERS

When the designer wishes to use a larger, more rigid shaft, without increasing the size of the housing bore, he utilizes another advantage of HYATT separable bearings. He can eliminate the inner race of the separable inner race HYATT bearing types and operate the bearing rollers directly on the suitably hardened and ground shaft. Space usually occupied by the inner race is available for a larger shaft.

3 REDUCED HOUSING BORE SIZES

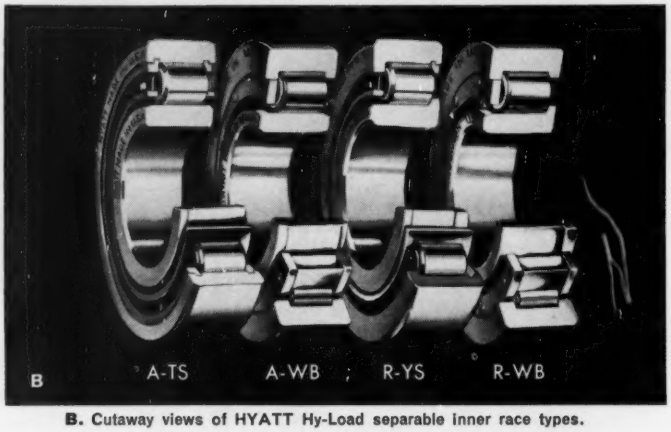
On the other hand, when space limitations force you to reduce the size of the housing bore without decreasing shaft diameter, versatile HYATT separable bearings are again the answer. This time you merely eliminate the outer race of one of the separable outer race HYATT bearing types—and operate the rollers directly on the suitably hardened and ground bore. You save the space normally occupied by the outer race.

And, of course, in applications where it is advisable to retain the complete bearing parts as a unit, HYATTS are available in non-separable assemblies.



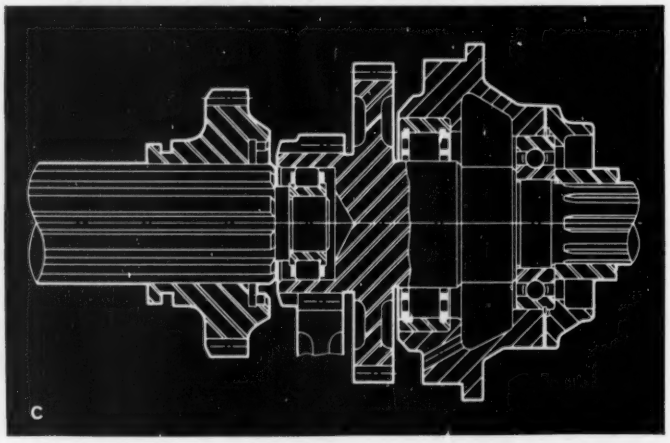
A. Cutaway view of HYATT Hy-Load separable outer race types.

A-1. Cutaway views of HYATT Hy-Load non-separable types (right).



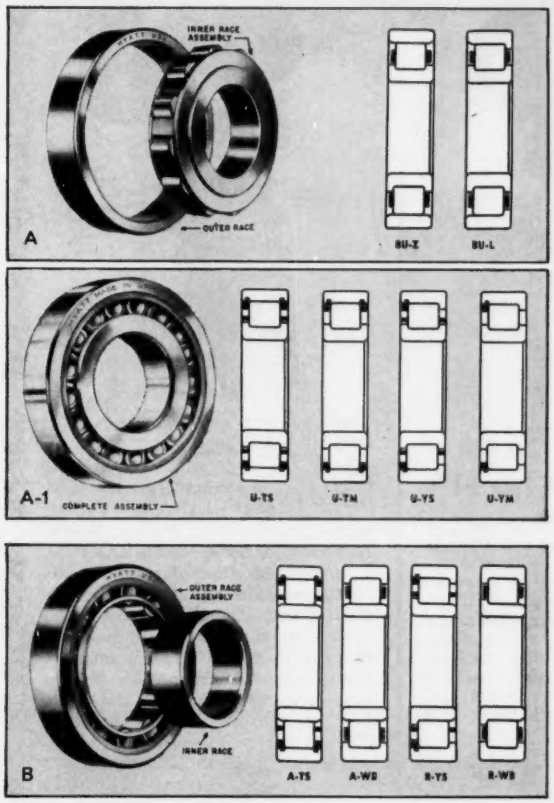
B. Cutaway views of HYATT Hy-Load separable inner race types.

C. Typical transmission application: Pilot bearing is BU-Z type without outer race, operating directly on hardened and ground gear bore, and an A-TS with inner race omitted operating directly on the shaft.



LINE FOR MACHINE DESIGN

SEPARABLE RACE ROLLER BEARINGS *with* INTERCHANGEABLE PARTS



Design engineers have come to recognize—and deal with—one stubborn fact in their business.

The stubborn fact: *Every bearing application has its own peculiarities.*

The way to deal with it: *Use the HYATT LINE!*

The core of the Hyatt Plan is simply this. Hyatt's separable race roller bearings—with interchangeable parts—permit you to improve machine design. They encourage improved machine design because they are adaptable to highly individual and unique applications.

Naturally, HYATT cylindrical bearings have more radial load-carrying capacity. Their true rolling action offers the lowest roller bearing friction. But the shrewd engineer looks beyond these basic life, load and speed relationships. He studies the installation, sealing, retainment, assembly and maintenance requirements of each individual bearing application.

In short, he uses the HYATT LINE for best results.

Pick up the phone the next time you want to review your bearing applications—for an overall production or performance advantage for your product. Call your nearest HYATT sales office.

You'll find the best roller bearing engineers anywhere at the other end of the line.

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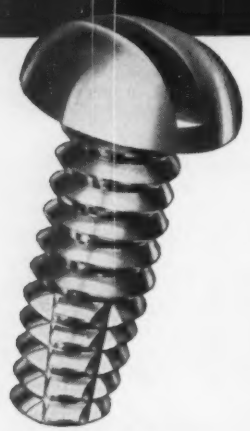
IN ROLLER BEARINGS, HYATT IS THE WORD FOR GM RELIABILITY

HYATT BEARINGS DIVISION · GENERAL MOTORS CORPORATION · HARRISON, NEW JERSEY

Got a problem that calls for thread-cutting screws?

PARKER-KALON offers three new, improved thread-cutting screws for every application in every material



1 New, Improved P-K Type F*

. . . hardened thread-cutting screws developed for use in friable, granular or brittle material. The pilot, with its five tapping flutes, cuts a machine screw thread as the screw is turned in. The Type F is ideal for making fastenings to ferrous and non-ferrous castings, bronze or brass forgings, heavy gage sheet metals, structural steels, plastics and resin-impregnated plywood.

2 "Pentap"... the new, Improved P-K Type B-F*

(formerly F-Z) combining the five thread-cutting flutes of the Type F screw with the coarse-pitch, widely-spaced threads of the P-K Type B. The thread-cutting "Pentap" Type B-F distributes cutting pressure evenly, lets chips drop to the bottom of the hole, and prevents cracking of material. It is designed for making fastenings to comparatively thin sections and bosses in friable and brittle plastics.

3 P-K® Type L†

. . . is a completely new and improved thread-cutting screw developed by Parker-Kalon especially for use in Nylon. The Type L functions as a combination thread-cutting and thread-forming screw in that it cuts a small amount of the Nylon to allow the full diameter threads to form. Type L offers a particular advantage in Nylon assemblies which must be disassembled for service, because *the P-K Type L can be removed and replaced without stripping or galling.*

The five cutting flutes on the new, improved P-K Type "F" and "BF" reduce pressure development by 80 percent! The completely formed threads on these screws have sharper cutting edges, and 5 deep flutes that are of continuous depth. These features make for better clearance of the accumulated material and assure minimum stresses in driving, and avoid the possibility of stripping or galling.

FOR SEMS . . . and Neoprene or Nylon washer STAPS® in thread-cutting and thread-forming tapping screws, or machine screws in any kind of pre-assembled fastener-washer combination, P-K can supply them, too!

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*Patent Pending †U. S. Patent 2,350,348

FOR SAMPLES OF P-K THREAD-CUTTING SCREWS AND SEMS, CALL YOUR LOCAL P-K "BULK-STOCKING" DISTRIBUTOR

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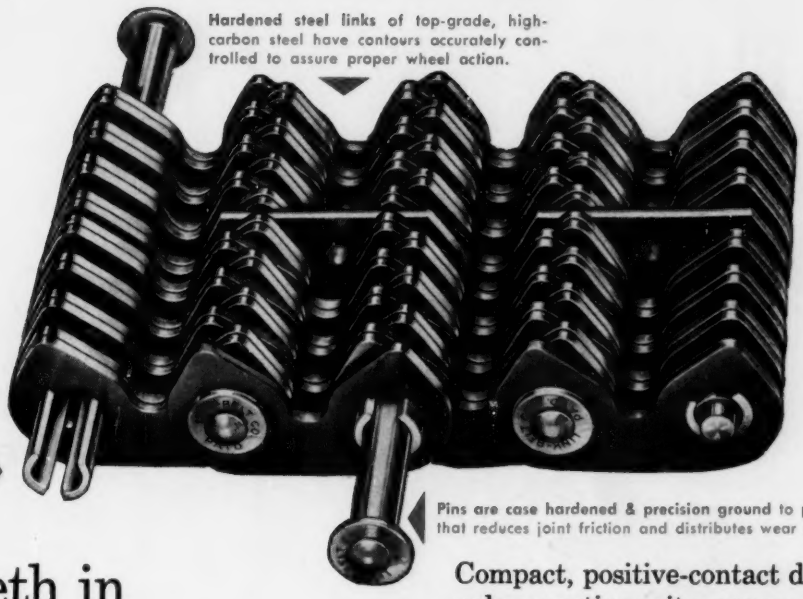
Hardened steel links of top-grade, high-carbon steel have contours accurately controlled to assure proper wheel action.
Bushings of specially selected steel are case hardened to take joint wear and prevent elongation of link hole.
Pins are case hardened & precision ground to permit free rotation that reduces joint friction and distributes wear over entire surface.

The teeth in Link-Belt silent chain put the bite on drive costs

Compact, positive-contact design reduces entire unit expense

There are big savings to be found by switching to modern, versatile Link-Belt silent chain drives. Smooth, positive engagement prevents slippage, eliminating wasted horsepower. Long life—continuous operation with minimum maintenance for many years is common—keeps production costs down.

Now consider these additional advantages: dependable operation under extremes of temperature and humidity; easy assembly in tight spaces, permitting built-in drives, compact housings; space saving and efficiency on extremely short centers at ratios as high as 10-to-1.

Link-Belt silent chain is available in a full range of types and sizes for either large or fractional-horsepower drives. For full details, call your nearby Link-Belt office. Look under CHAINS in the yellow pages of your phone book. Ask for Book 2425.

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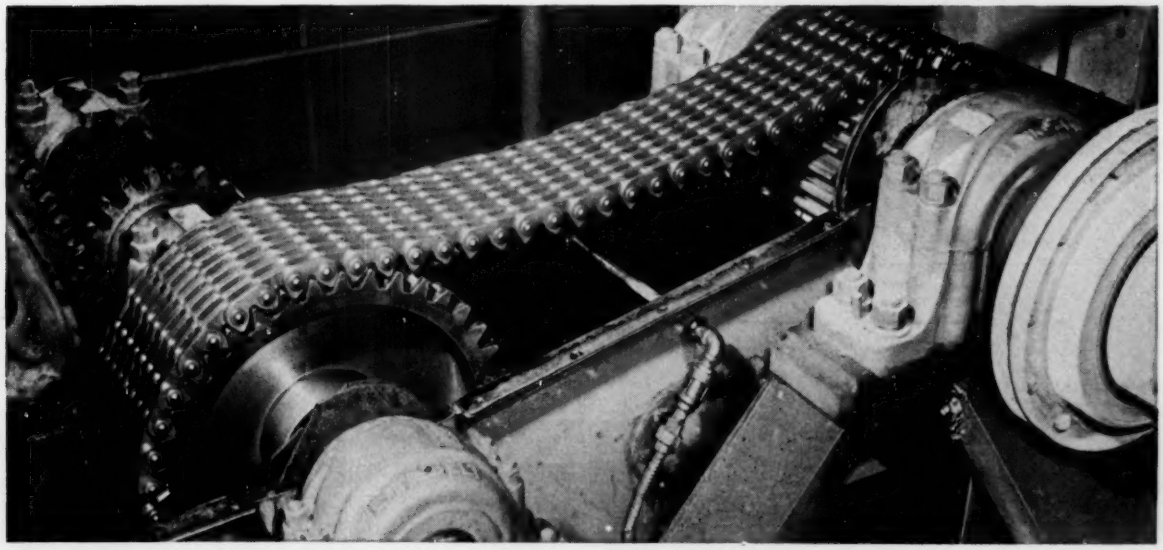
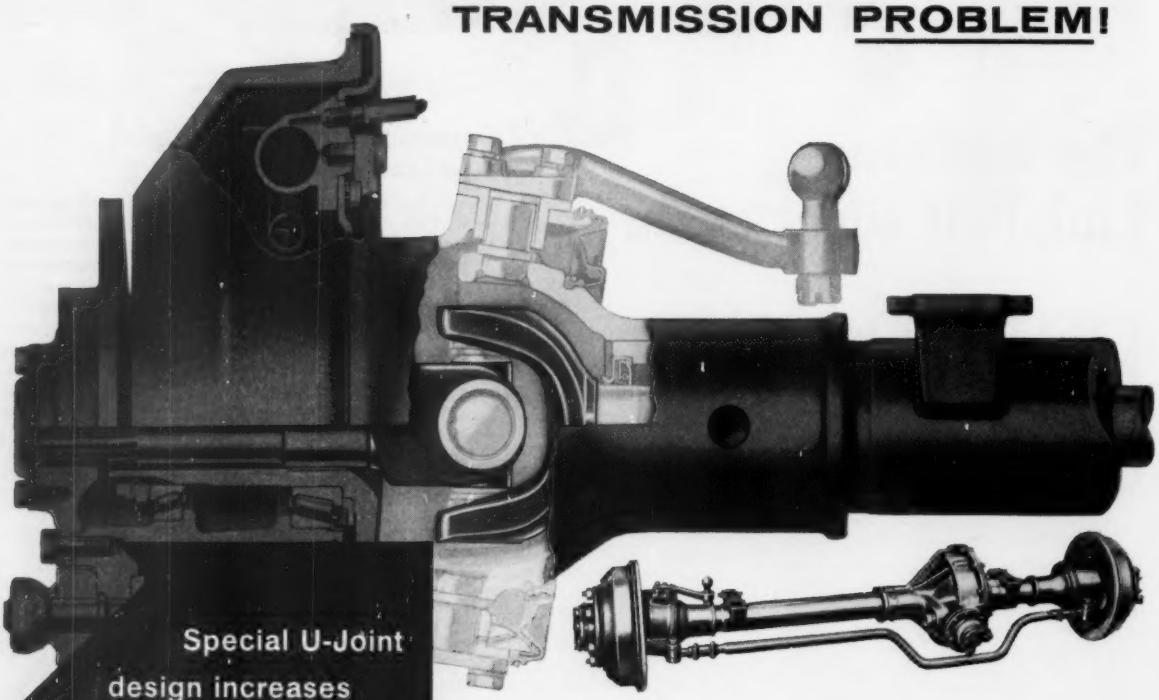


BLOOD BROTHERS UNIVERSAL JOINT

SOLVES ANOTHER POWER TRANSMISSION PROBLEM!



Special U-Joint design increases axle torque capacity... yet lowers axle production costs!

Working with a major manufacturer of truck axles, Rockwell-Standard engineers developed a new design for a front steering, driving axle that uses a single carden universal joint in place of the expensive and complicated constant velocity type previously used on a special all-wheel-drive vehicle.

The result: *An axle that provides substantially increased torque capacity . . . at a considerable savings in manufacturing costs!*

Whether you are designing a new product or seeking to improve an existing one, consult Rockwell-Standard engineers for specialized help in meeting your universal joint needs. Chances are, a Blood Brothers product will not only increase performance – but save you time and money as well.

For further product information write for Bulletin

Another Product of...

ROCKWELL-STANDARD CORPORATION

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The BELLOWS AIR MOTOR — A 20-page booklet describes the function, applications, valving arrangements, mounting styles and other pertinent information about the Bellows Air Motor. Model specifications are completely covered. **Bulletin BM25.**

VALVAIR HEAVY-DUTY CYLINDERS—Built to ASA standards in a full range of bore sizes and stroke lengths. Construction details, specifications, dimensional data sheets. **Bulletin VC-800.**

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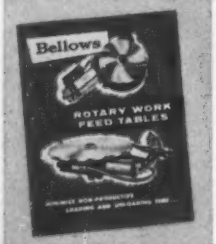

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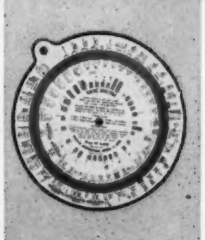

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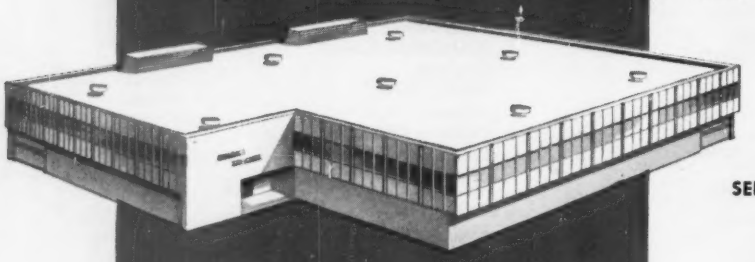
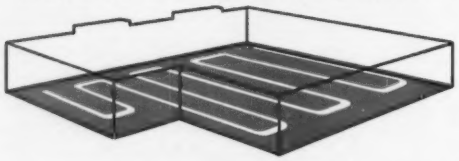
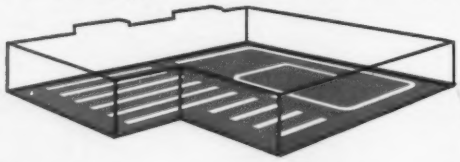


Today, your production line can move in a serpentine pattern



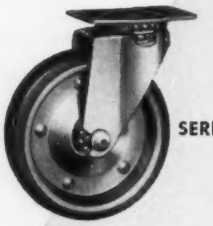
. . . tomorrow it can be changed to a straight-line or circular flow



A fluid Faultless Castered production line is quickly reshaped as needed . . . to suit new products, design changes, retooling, time-and-motion study recommendations, etc. Also Faultless Castered trucks, dollies, racks, carts can transport your manufactured products outdoors for yard stocking. Whatever your production line load requirements, floor surfaces, space limitations, Faultless engineers the precision casters to meet your specific requirements and limitations.

ASK YOUR DISTRIBUTOR: Your nearby Faultless Industrial Distributor maintains a substantial inventory of Faultless Casters for immediate delivery. He and one of the strategically located Faultless Sales Engineers are available to work with you on every handling problem in your plant. Or write for complete information.

GENERAL DUTY SERIES 100 CASTER



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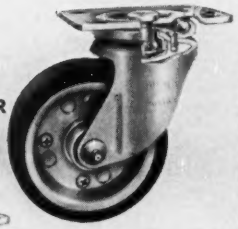
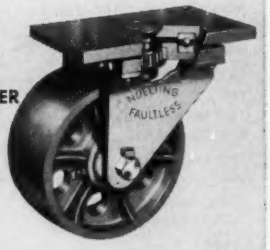


MEDIUM DUTY SERIES L900 CASTER

HEAVY DUTY SERIES H900 CASTER



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New product information for fiber glass reinforced plastics industry

fiber glass news

PPG fiber glass makes products better, safer, stronger, lighter

FEBRUARY, 1961

PPG ANNOUNCES NEW FIBER GLASS CHOPPED STRAND MAT

PPG Customers Praise New Reinforcing Mat

Samples of the first runs of the new PPG Chopped Strand Mat were shipped to several PPG customers for use in production trials.

These customers obtained excellent results. One panel manufacturer reported the new product helped him produce highly translucent corrugated sheets with the fiber pattern almost indistinguishable. Wet-out characteristics were superior to other products he had tried. Based on these trials, he has placed a sizeable reorder.

Similar reports have been received from other manufacturers.

PPG Offers Technical Help to Manufacturers

Samples of PPG's new Chopped Strand Mat are available to manufacturers for trial runs on their own equipment.

If you need technical assistance on these runs, a member of PPG's technical staff will be glad to answer any questions you may have concerning the use of this new product. If you wish, he will come to your plant to help run tests, demonstrate techniques and help adjust machinery settings to obtain best results.

Quality Product for Sheets, Boats, High Pressure Molding

Now available from PPG is a new high quality fiber glass reinforcing Mat.

Produced from PPG's new chopped strand with a specially developed binder, this new mat has excellent wet-out characteristics, provides highly uniform fiber distribution and weight; and because it produces a pure whiteness, it eliminates any problem of discoloration of finished laminates.

Three Types Available

Type AC Mat has been designed especially for corrugated, embossed or flat translucent fiber glass decorative and structural panels where clarity and lack of fiber pattern is important.

Type AB Mat is ideal for boat manufacturing and other layup jobs where strength, good draping and fast wet-out are needed.

Type AM Mat is available for use in high pressure molding to produce strong, uniform finished products.

New Mat Produced In Complete Size Range

PPG Chopped Strand Mat is produced in widths and weights to meet your specifications.

Announced weights per square foot in ounces are ¾, 1, 1¼, 1½, 2 and 3. Width range includes 40″, 56″, 60″ and 76″. Other widths are available by special order.

Mats are packaged wound on 4″ I.D. tubes according to width dimensions.

Literature Available

Complete information on PPG Fiber Glass Chopped Strand Mat is available through any of the PPG Fiber Glass Sales Offices listed below, or by writing PPG Fiber Glass Division direct. Get your copy now, and learn how you can benefit from this new mat product.

Where to Buy It

PPG Fiber Glass Chopped Strand Mat can be ordered through any PPG Fiber Glass Sales Office or regional distributor, or can be ordered direct by writing or calling *Pittsburgh Plate Glass Company, Fiber Glass Division, Room 1668, One Gateway Center, Pittsburgh 22, Pennsylvania.*

Circle 444 on Page 19

FIBER GLASS PITTSBURGH PLATE GLASS COMPANY

Sales Offices: Atlanta, Boston, Buffalo, Charlotte, Chicago, Cincinnati, Cleveland, Dallas, Denver, Detroit, Houston, Los Angeles, Louisville, Milwaukee, Miami, Minneapolis, New Orleans, New York, Philadelphia, Pittsburgh, St. Louis, San Francisco, and Seattle.

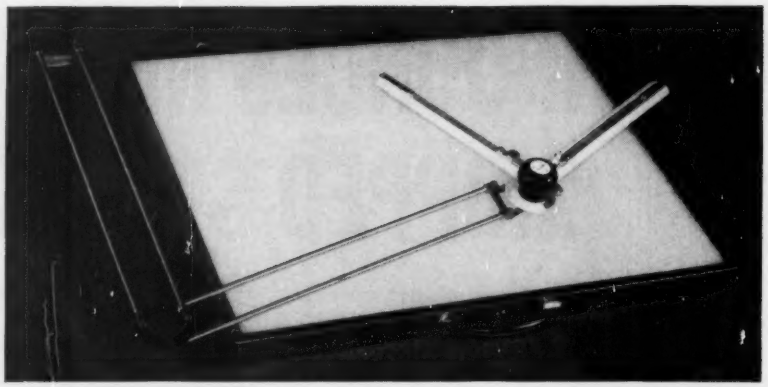
FROM OZALID®

to help you do your job even better

These work-savers from Ozalid do more than save you time, trouble and money. They also give you an end result that's top quality by *any*one's standards.

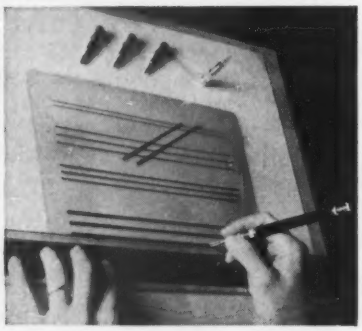
For samples or a demonstration, get in touch with your nearest Ozalid man, or write Ozalid, Johnson City, N. Y.

Ozalid, A Division of General Aniline & Film Corp., Johnson City, New York. In Canada: Hughes-Owens Co., Ltd., Montreal

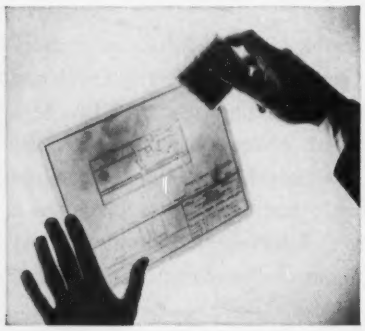


Trace at your drawing board. New Porta-Trace is lightweight, illuminated. Less than 2″ thin, can be used with drafting machine or under string-type parallel rule. Ideal for inspection of textiles, papers, films. Stores on end like a book. Five sizes.

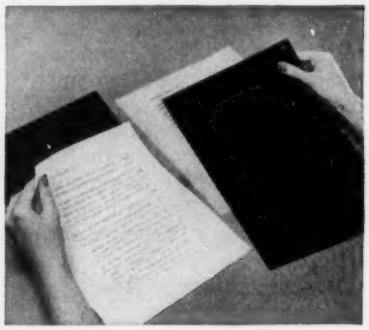
Cut drafting time and work, maintain perfect *accuracy* with a Nestler drafting machine. No need to juggle T-squares, triangles, scales, and protractor. Built-in hatching. Adjustable zero point. Positive scale locks. Seven different models.



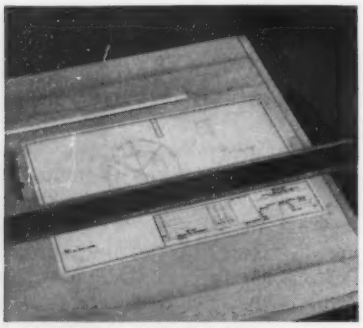
1000 feet on one filling. Grafika universal drafting pen, with unique capillary ink control, gives long, even flow; no blotting or line spread. Precise line-width settings. With only 11 nibs, Grafika covers full scope of ink drafting.



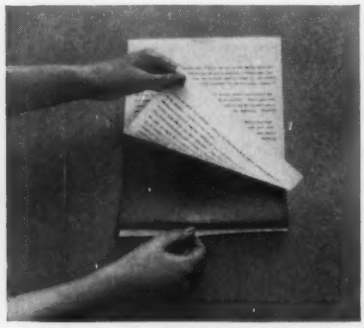
Wipe-clean drafting film. Duratrace, made with Du Pont Mylar®, is also tear-proof, erasable, dimensionally stable. Velvet-smooth drafting surface. Perfect master for design drafting, printing circuit masters, comparators, map making, etc.



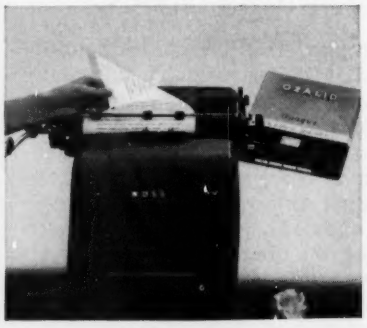
Finest repro black carbon film. Duratrace® Carbon has highly opaque coat, tough Du Pont Mylar® base. Superb backing for extra-clean, sharp, high-contrast masters. Use also for mechanical negative and overhead projection.



Tracing vellum for top results. Draftrace stands up under erasures, rough handling, aging. 100% rag content is permeated with new water-clear resin, won't yellow, won't leak. Gives high repro speed, excellent contrast, fine prints.



To simplify preparation of originals for whiteprint repro, use Transalid Translucent Master Sets. They combine Ozamaster translucent bond and opaque carbon paper in handy unit. Quick, clean, sure. You'll wonder how you got along without them.



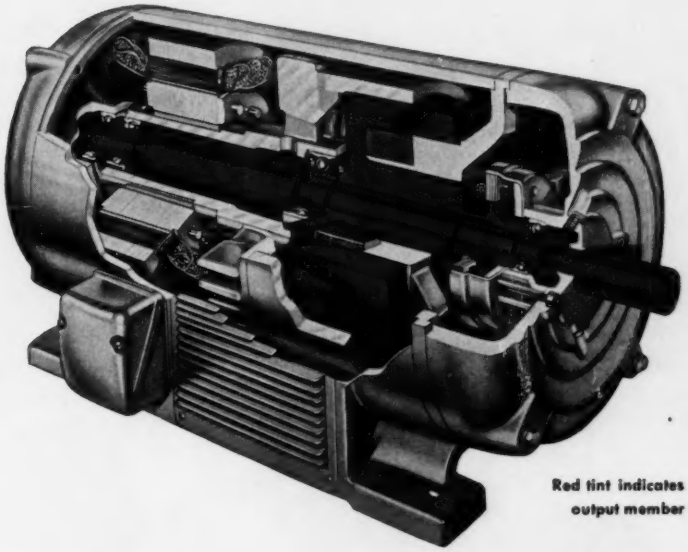
For easy-read whiteprints, carbon-back your originals with Ozalid opaque carbon papers. Distinctive orange color prevents light leaks. Gives you sharp, clear prints with strong image-to-background contrasts . . . perfect copies every time!

NOW— another FIRST by the Originator of Eddy-Current Equipment

NEW

DYNAMATIC®

Model 905 Ajusto-Spede® Drive



Red tint indicates output member

Extends Capacity Range to 15 HP in the Popular Quill-Type Design

The addition of the new model ACM-905 to the famous ACM-903 and ACM-904 lines of Dynamatic Ajusto-Spede Drives makes the desirable features of Dynamatic Quill-Type design available for many new applications.

Dynamatic Ajusto-Spede Drives provide controlled adjustable speed from an AC power source. Standard control features include on-off clutch control, infinite speed adjustment, constant speed regulation, and jogging. Any of a variety of special features may be easily and economically added to the standard control.

All Quill-Type models are available with either eddy-current, Dyna-torQ, or fail-safe brakes.

An Ajusto-Spede Drive, a control unit (either electron tube or transistorized magnetic amplifier), and a push-button station comprise a compact, easily installed, low-cost drive package.

Check these Ajusto-Spede® Advantages

- ★ **Infinitely adjustable speed from AC power**
- ★ **Simplified construction**
- ★ **Compact design**
- ★ **Wide speed range**
- ★ **Remote control**
- ★ **Stationary field coils**
- ★ **Excellent performance characteristics**

Send for Illustrated Descriptive Literature

EATON

DYNAMATIC DIVISION

MANUFACTURING COMPANY

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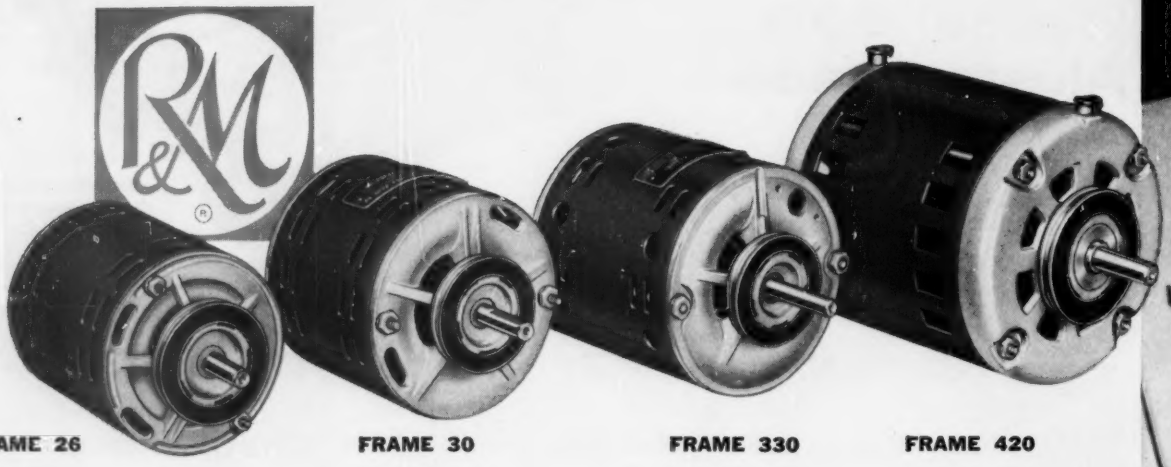
YOU CAN SEE THE EXTRA

DEPENDABILITY

BUILT INTO R&M FRACTIONALS!



FRAME 26 FRAME 30 FRAME 330 FRAME 420

new broad line offers ratings from 1/100 through 1/3 hp!

R&M's Special Application AC Motors feature extra dependability for your customers and offer wide design flexibility to you! Silent operation, compact size and minimum maintenance make these FHP motors ideal for powering office appliances, fans and blowers, small motor driven tools and countless other products. You can select from four frame sizes, 3" through 4¾" dia.; sixteen ratings from 1/100 through ⅓ HP; two, four and six pole speeds; three mounting arrangements; and four electrical types—capacitor start induction run, split phase, permanent split capacitor or polyphase.

For long-life operation, Mylar is used to line the burr-free slot cells. Mylar has 8 times the dielectric strength of conventional insulation and stubbornly resists tearing and aging, to provide virtually permanent protection. Venturi baffles in each end head direct fan-driven air over and around coil ends in a "washing" action that quickly carries off heat, keeping the motor well within its rated temperature rise. The absence of centrifugal mechanisms and brushes further minimizes maintenance problems.

R&M Special Application Motors are available in standard off-the-shelf designs. Should you require a special custom motor, R&M will recommend the optimum design, at no obligation. Write today for new R&M bulletin 445-MD

ROBBINS & MYERS, INC., Springfield, Ohio

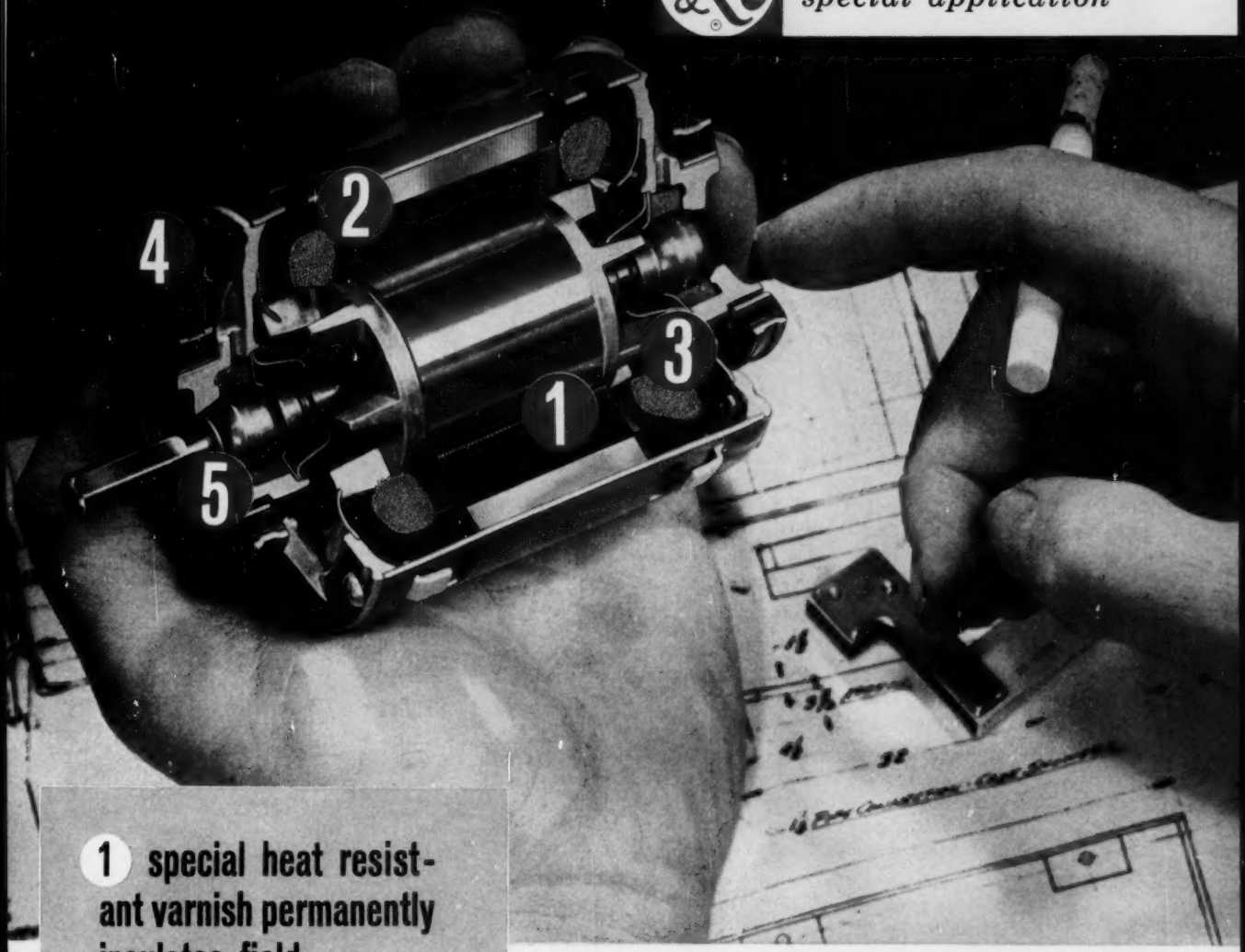
Fractional and Integral HP Electric Motors • Electric Hoists and Overhead Traveling Cranes • Moyno® Industrial Pumps
Propellair® Industrial Fans • R & M Hunter Fans and Electric Heat • Trade-Wind Range Hoods and Ventilators
Subsidiary companies at: Memphis, Tenn., Pico Rivera, Calif., Brantford, Ontario.

Circle 447 on Page 19

R&M

FRACTIONAL MOTORS

special application



1 special heat resistant varnish permanently insulates field.

2 Mylar* insulation locked in burr-free slots.

3 high velocity air flow cools motor windings.

4 lightweight, die-cast aluminum end heads.

5 choice of sleeve or ball bearings.

*DuPont registered trademark.

REMEMBER COLLAR BUTTONS?

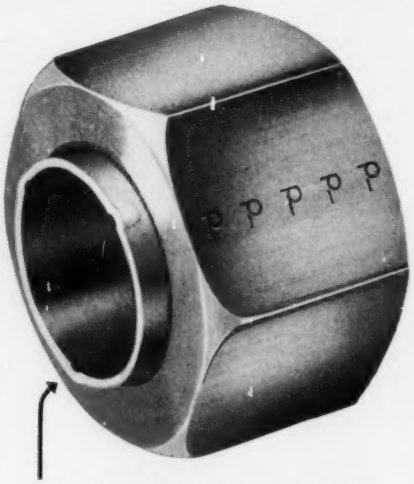
NOW **PARKER** HAS ELIMINATED A MORE SERIOUS ANNOYANCE ...LOST TUBE FITTING FERRULES!

A simple change in the design of Parker "Intru-lok®," the positive, bite-type Parker fitting for copper, aluminum or plastic tubing, has solved an age-old problem.

Small three- and four-piece tube fittings have long been a pain in the neck on applications where it is necessary to remove the nut from the fitting. The ferrule(s) fall out and promptly disappear. If and when found, they often get put in backwards. Sometimes they never get put back at all. Result, in either case: a leaking joint.

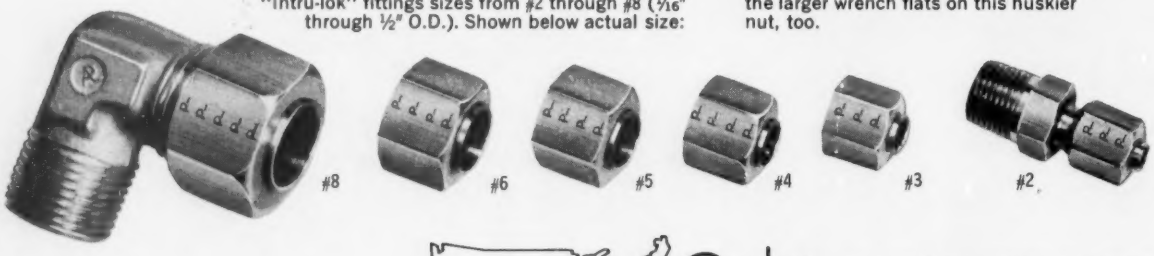
Now Parker has developed a snap-in, captive ferrule for "Intru-lok." You can take it out of the nut, "on purpose," but you can't drop it out accidentally.

You get all the leakproof safety of a three-piece fitting with positive "bite." You also get the convenience, the quick, easy assembly of a two-piece fitting. The easiest fitting to install has been made even easier. Write for new "Intru-lok" dimensions and prices today.



Three "detents" hold the "tail" of the new ferrule in the nut. Also, the larger hole in the nut makes tube bends closer to the fitting possible. Note the larger wrench flats on this huskier nut, too.

The new nut with captive ferrule is available on all "Intru-lok" fittings sizes from #2 through #8 (1/16" through 1/2" O.D.). Shown below actual size:



PARKER HANNIFIN CORPORATION

Parker FITTINGS AND HOSE DIVISION
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PNEUMATIC AND HYDRAULIC SYSTEM COMPONENTS
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3278-PH

Circle 448 on Page 19

Circle 449 on Page 19→

NEW General Electric Industrial Miniature Oil-tight Push Buttons Give You . . .

COLORS UNLIMITED, OVER 40% SPACE SAVINGS

Now you can reduce the size of your control panels at least 40 percent. New General Electric miniature oil-tight push buttons require only about half the panel space of heavy-duty oil-tight units.

Improve machine appearance. Unlimited color combinations are available in operators and rings to complement your equipment—provide positive color identification from any angle. Color is permanent; won't wear off, chip or fade.

Industry's first full line allows you to design entire panels with miniature units. Choose combinations of: standard (with or without guard) and mushroom-head push buttons; wobble stick operator; maintained and spring-return selector switches; coin-operated, cylinder-lock and bat-lever selector switches; resistor and transformer-type illuminated push buttons, indicating lights, and push-to-test lights. G-E miniature push buttons are available in complete units or as separate components, to allow you to make up any form you need with a minimum stock.

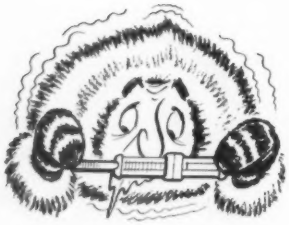
Call your General Electric sales engineer or distributor today, or write for publication GEA-7127, General Electric Co., Schenectady 5, N. Y. 811-22

Progress Is Our Most Important Product

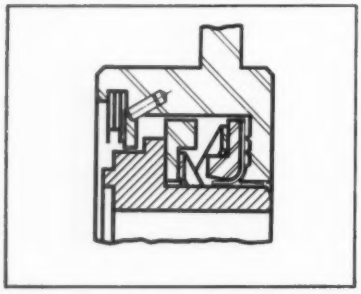
GENERAL ELECTRIC

Secrets of Successful Seal Design

Cryogenics - No. 2 of a Series



The sealing of very cold liquids with mechanical seals has opened a new dimension in cryogenics — and, with it, new problems. For instance, many mechanical seals which are satisfactory for liquid oxygen service at –280°F may lose one-half or more of their service life when used with liquid nitrogen at –320°F.



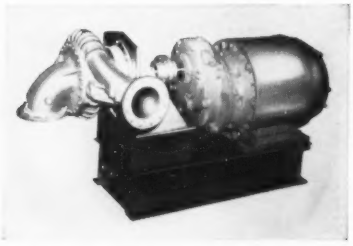
Sealol LOX Seal — *thin film, Kel-F* packing .005" thick, replaces the customary O-ring or V-cup packing, thus reducing axial drag caused by elastomer shrinkage.*

Liquid oxygen, or LOX, is probably the simplest of the cryogenics to handle since it appears to supply some small amount of lubrication, perhaps in the form of an oxide on the faces of the mating ring and seal ring. However, lubrication values of liquid nitrogen and hydrogen are practically nil, and we must select face materials which are designed for "dry" operating conditions.

**TM Minnesota Mining & Mfg. Co.*

HOT OR COLD

It is curious how our technology for solving high temperature, dry-running seals now unexpectedly finds a place at the other end of the temperature spectrum. In both situations, lack of lubrication is at the heart of the problem. Incidentally, our specially treated dry-running seals have met life requirements of 3,000 hours on a shaft turning at 7,000 RPM, ambient temperatures to 250°F and intermittent pressures to 650 psi when water was pumped for two minutes once every four hours.



Equipped with standard Sealol LOX Seal, *this 500 GPM centrifugal pump is part of skid-mounted LOX ground support equipment manufactured by the Cambridge Division of Standard Steel Corporation. Discharge pressure is 100 psig max., 2380 RPM operating speed.*

SEAL LOCATION

Pump design and general operating conditions will have a lot to do with seal performance when handling cryogenics. Provide, if you can, for the seal to operate directly in the liquid being sealed. This will give you the benefit of whatever lubrication value the fluid has, plus better heat transfer conditions, and is usually preferable to sealing the gases themselves. When the seal is operating in the vapor stage, the temperatures ambient to the seal are usually slightly higher than if the seal were immersed in the fluid.

APPLICATION REQUIREMENTS

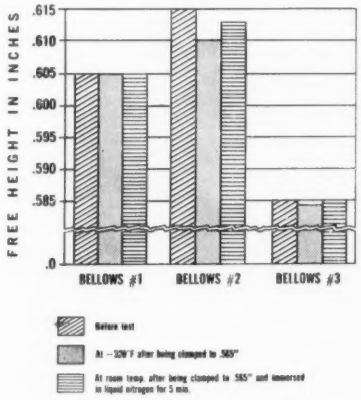
Our missile customers usually think of seal life in terms of minutes and seconds, or at the most, in hours. On the other hand, our industrial customers want LOX transfer pump seals to stand up for years. In the latter case, speeds and pressures are considerably lower, and under favorable conditions, a life of 1,000 hours is certain.

At high rubbing speeds, say 10,000 fpm and more, "burn" marks are frequently observed on the rubbing surfaces of the seal and mating rings in spite of the fact that the temperature of the cryogenic being sealed is hundreds of degrees below zero.

High spring loads will frequently be the villain behind this curious phenomenon. Seal designers have been leaning towards higher spring loads in order to overcome the drag caused by stiffening of the elastomers at low temperatures. If you notice burn marks on your mating rings, check for excessive spring loading in relation to face rubbing speeds.

BELLOWS SEALS

Sealol balanced-pressure bellows seals, on the other hand, provide a positive answer to this problem because metal bellows offer no temperature induced resistance to axial movements as do elastomers. As a result, spring loads can be reduced to any level consistant with optimum face loading.



Cold-soak tests *have indicated that bellows spring characteristics (Stainless #300 Series Steel) remain unchanged for all practical purposes, before, during and after immersion in cryogenic liquids.*

We have learned the hard way that there are no pat answers to problems involving cryogenics, because each requires special consideration. We'd be glad to exchange information and, if you wish, submit a proposal for your specific problem.

SEALOL

INC.

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New York — Yukon 6-0288
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first in silicones

Dow Corning

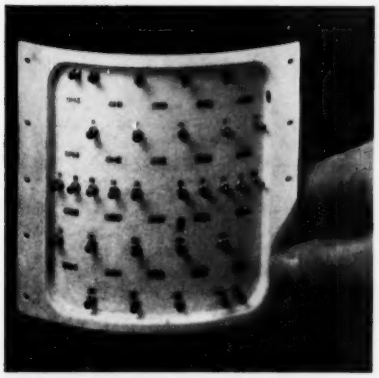
SILICONE NEWS

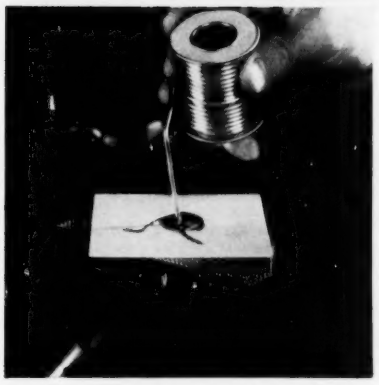
for design and development engineers • No. 80

When Going Is Rough

LOX cold . . . high Mach heat . . . corona . . . ozone . . . launching and sonic shock—more and more environmental challenges are being met by Dow Corning Silicones.

Take silicone-glass laminates made with Dow Corning resins, as examples. Silicone-glass laminates have good mechanical strength, low loss factor, low moisture absorption, excellent resistance to arcing, corona, corrosive atmospheres, fungus and contaminants. What's even more important, they retain these properties despite elevated temperatures, storage, environmental aging, rapidly changing ambients, vibration and shock. Heat resistance of silicone-glass laminates is exceptional . . . up to 250 C continuous for years . . . much higher for short time periods.





Lear, Inc., of Grand Rapids, Michigan mounts the mica capacitors of their Model 2013J Stable Platform for missile guidance systems on this formed silicone-glass laminate terminal board, made by Silicone Insulation, Inc., Bronx, N. Y. *(Cont. Pg. 2)*

ALWAYS READY FOR USE

Cabin decompression is a possibility (even though remote) in a jetliner flying at 30,000 feet or higher. To meet this eventuality, high flying commercial jets now provide the ultimate in passenger safety with automatic positioning oxygen masks made of Silastic®, the Dow Corning silicone rubber.

If decompression should occur, these silicone rubber masks will immediately pop out of their storage compartments, ready for use by seat occupants. Why are these masks made of Silastic?

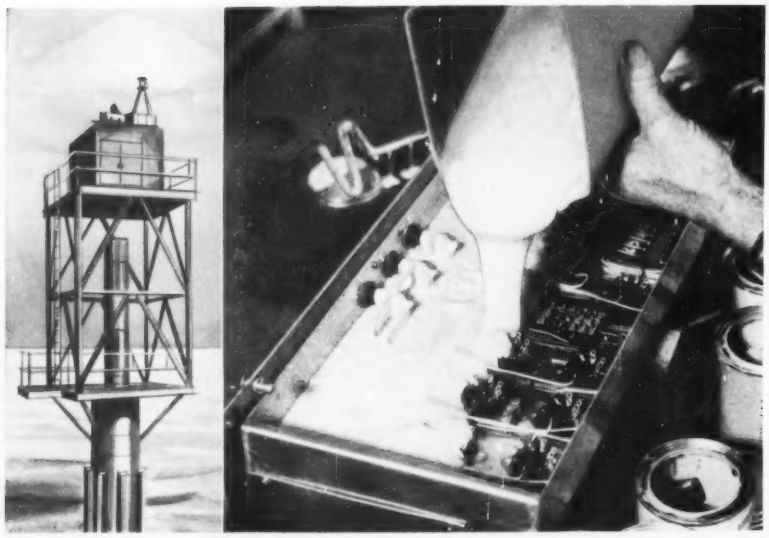
Here are the requirements as enumerated by the manufacturer, ARO Equipment of California, Los Angeles. Although it's stored crushed in a small area, the mask must return to its original shape without damage. It must be odorless; nontoxic in direct contact with skin; easy to clean and sterilize; flexible to −65 F; withstand a test of 72 hours at 160 F temperature without visible damage; and, be resistant to the cracking and checking effects of

oxygen and ozone. Futhermore, the masks must retain these properties and remain reliable for an "in service" life of more than three years! Silastic meets *all* of these operating and storage requirements!

Over 100 rubber companies now manufacture parts from Silastic. For a list of these suppliers, circle . . . . **No. 241**

FOR DATA RELATING TO THESE ARTICLES, CIRCLE REFERENCE NUMBER IN COUPON ON NEXT PAGE OR REFERENCE NUMBER ON READER SERVICE CARD

MORE



TO REDUCE HAZARDS

Development of offshore oil fields presents problems not generally encountered ashore. For example, whoever worried about the shipping hazards of drilling and pumping rigs? This was the problem that led Automatic Power Inc. of Houston, Texas to design their DA-20 Dies-L-Air offshore warning systems.

An essential element to Automatic Power's new warning signal is the DAE 12 volt d-c controller that monitors operation of the entire warning signal system including the diesel engine, air system, control circuitry, and horns. More dependable than a human attendant, the controller immediately detects any irregularity of operation of the Dies-L-Air and automatically starts the standby system.

Obviously, reliability is essential. And that's why engineers at Automatic Power selected Silastic RTV to embed and protect all tube sockets, connections, wiring and other components in the controller chassis. Silastic RTV is the fluid silicone rubber that cures without heat. Being resistant to heat, ozone, corona, weathering, and oxidation, it keeps the controller operable in spite of corrosive salt water spray and wind-driven rain. Extreme temperatures have no effect on this silicone rubber—it remains serviceable from —70 to 500 F! Silastic RTV pours easily as a liquid and cures to a firm, rubbery mass with good dielectric and physical properties.

To obtain more detailed information about Silastic RTV, circle . . . . *No. 242*

SILICONE-GLASS *(Cont.)*

Tolerance requirements, plus assembler variations dictated a material that could be formed . . . would withstand soldering temperatures . . . would hold its form despite environmental extremes. Environmental conditions are: —40 to 160 F; shocks of 30 G's for about 11 milliseconds each; complex wave vibration for 20 minutes in each plane as follows—30-100 cps: 0.46 g^2/cps and 100-2000 cps: 0.015 g^2/cps.

Glass laminates made with Dow Corning silicone resins are available from leading laminators. For further information and list of laminators, circle . . . *No. 243*

new literature and technical data on silicones

Motor Stability with Silicones—Complete data on an entirely new silicone impregnating varnish is available in this 4-page bulletin. Dow Corning 981 Varnish provides an exceptionally high order of heat stability and is applicable in Class A, B, F, or H systems. Graphs show specific gravity-temperature and viscosity-temperature curves. An entire page is devoted to the typical properties you can expect from cured 981 Varnish films. See if you'll want to specify Dow Corning 981 Varnish by writing for . . . . . *No. 244*

Greater Stability Plus—Silicone diffusion pump fluids make the operation of pumps more efficient over longer periods of time and under more adverse conditions. After as many as 1100 cycles of heating to operating temperature and partial cooling, with exposure to air during each cycle, silicone fluids do not decompose into gums or tars. Rapid recovery, quick pump-down, inertness, fine vacua and economy are other advantages of using heat-stable Dow Corning diffusion pump fluid. *No. 245*

Compiled for Advanced Research and Development Engineers, an eight-page reference provides a convenient guide to selecting the most suitable silicone fluid medium when designing damping, springing, coupling and related mechanical devices. Includes tables, graphs and detailed information about properties that enable Dow Corning silicone fluids to increase efficiency of existing designs and make possible new design changes. *No. 246*

Silicones in Industrial Finishes is the title of an article pointing up the advantages of silicone protective coatings. Excellent resistance to corrosion and heat have put these general weathering and low temperature silicone-based paints in great industrial demand for everything from smoke stacks and mufflers, to space heaters, refrigeration equipment, and open plant piping. This is an important reference for any designer interested in durable finishes for plant, equipment or end products. *No. 247*

Dow Corning Corporation, Dept. 4914, Midland, Michigan

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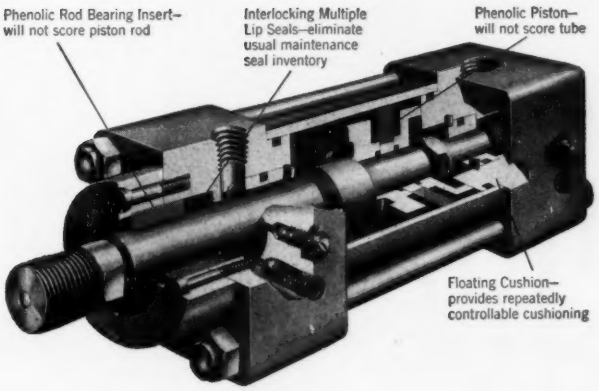
Fluid Circuitry News from Westinghouse

Industrial Product Division expands line

The Petch line of high quality air and hydraulic cylinders is now part of the line of Westinghouse Fluid Circuitry components. This acquisition makes it possible for us to offer industry the *most complete line* of air and hydraulic components for control systems to automate industrial production operations.


Phenolic Rod Bearing Insert–will not score piston rod
Interlocking Multiple Lip Seals–eliminate usual maintenance seal inventory
Phenolic Piston–will not score tube
Floating Cushion–provides repeatedly controllable cushioning

The Petch line of rugged, precision made cylinders include the following models:

Air & Low Pressure Hydraulic Cylinders

150 psi Air 500 psi Hydraulic
1″ to 10″ Bores
10 Standard Mountings

High Pressure Hydraulic Cylinders

1½″ to 6″ bores—2000 psi
8″ to 10″ bores—3000 psi
10 Standard Mountings

All Petch Cylinders conform to J. I. C. Standards.

FLUID CIRCUITRY... FOR TROUBLE-FREE AUTOMATION

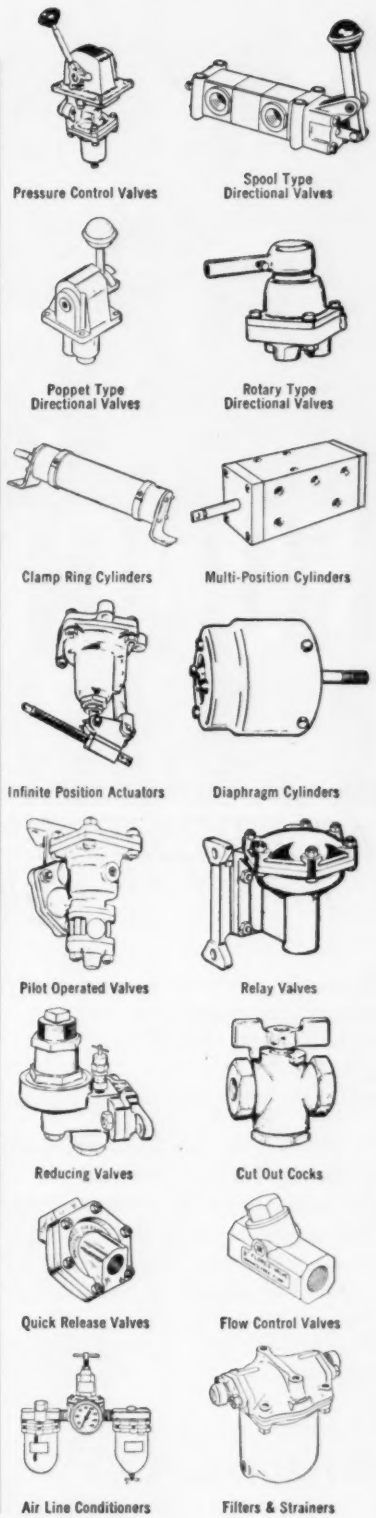
Fluid Circuitry is the application of fluid control systems to industrial production operations.

Fluid Circuits are economical, safe and precise. They are used to solve the most vigorous and complex control problems.

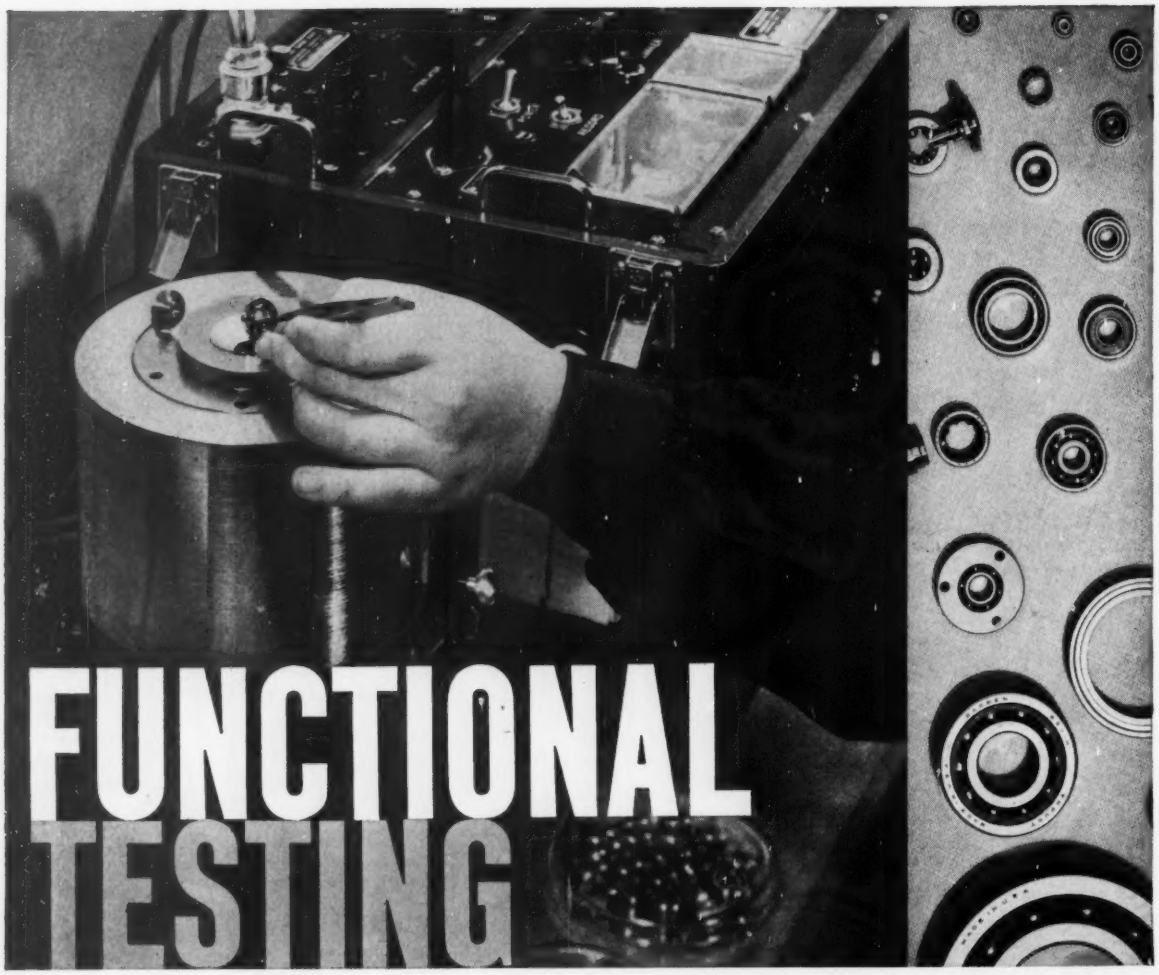
They contain reliable products to boost your production and cut your production costs.

For more information on Petch Cylinders and Fluid Circuitry ask for catalog A3-56.00.

See the Yellow Pages under Cylinders for the Name of Your Local Distributor, or refer to Sweet's Catalog, Product Design File.



WESTINGHOUSE AIR BRAKE COMPANY
INDUSTRIAL PRODUCTS DIVISION, WILMERDING, PENNSYLVANIA



FUNCTIONAL TESTING

ASSURES PREDICTABLE PERFORMANCE OF BARDEN PRECISION BALL BEARINGS

At Barden, each of the steps involved in the design, engineering, manufacture, assembly and testing of precision bearings has just one goal – to insure that, small quantity or large, every *Barden Precision* ball bearing will meet your performance requirements.

Functional testing – all important in accurately predicting bearing performance – is used throughout Barden's rigidly controlled production processes, from parts manufacture to final bearing inspection. Typical of the continuing efforts to develop advanced functional testing techniques is the Barden Torkintegrator.

This instrument, which provides extremely accurate response to bearing torque variations, is one of many Barden contributions to the advancement of precision bearing art. In fact, many of these Barden developments have now become industry standards.

Barden functional testing – together with Barden methods in manufacturing, quality control, bearing assembly, final inspection, lubrication and sealed packaging – is your assurance that with *Barden Precision* bearings you get consistent quality from the beginning to the end of each production run.

Barden is a major supplier of standard bearings in sizes from .0469" bore to over 3" O.D., all manufactured to *Barden Precision* standards of dimensional accuracy, uniformity and reliability.

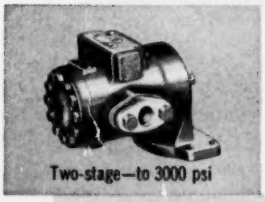
for reliability... specify

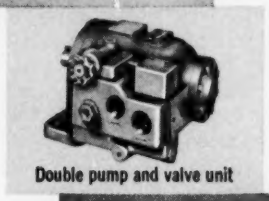
BARDEN PRECISION BALL BEARINGS

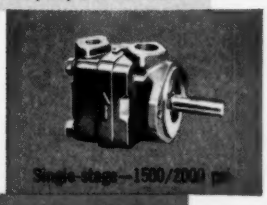
THE BARDEN CORPORATION, 234 Park Avenue, Danbury, Connecticut
Western office: 3850 Wilshire Boulevard, Los Angeles 5, California

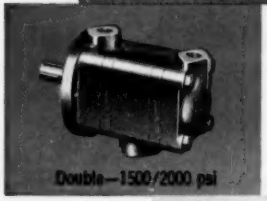
For top pump performance on every job!

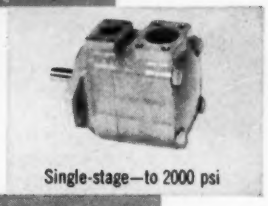
Single stage—to 1000 psi


Two-stage—to 3000 psi


Double pump and valve unit


Single-stage—1500/2000 psi


Double—1500/2000 psi

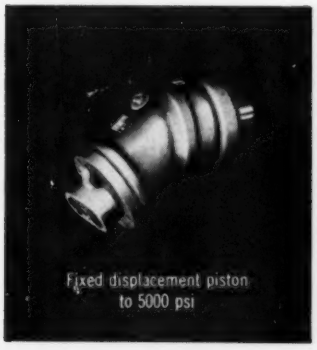

Single-stage—to 2000 psi

Double—to 2000 psi

Only Vickers offers you a complete line of hydraulic pumps tailored to suit your performance, life and price requirements.

* You can select from more than 500 standard models —vane and piston, fixed and variable displacement.
* You can choose models for use with oil or fire-resistant fluids—synthetic, water glycol and water-oil emulsion.
* You may obtain application engineering assistance from *specialists* responsible for a single line of hydraulic products.
* Your replacement units and parts are stocked in regional warehouses . . . unequaled field and shop repair service is provided by factory-trained, experienced technicians.
* You are assured of simplified service and reduced inventory requirements with Vickers replaceable cartridge and repair kits.

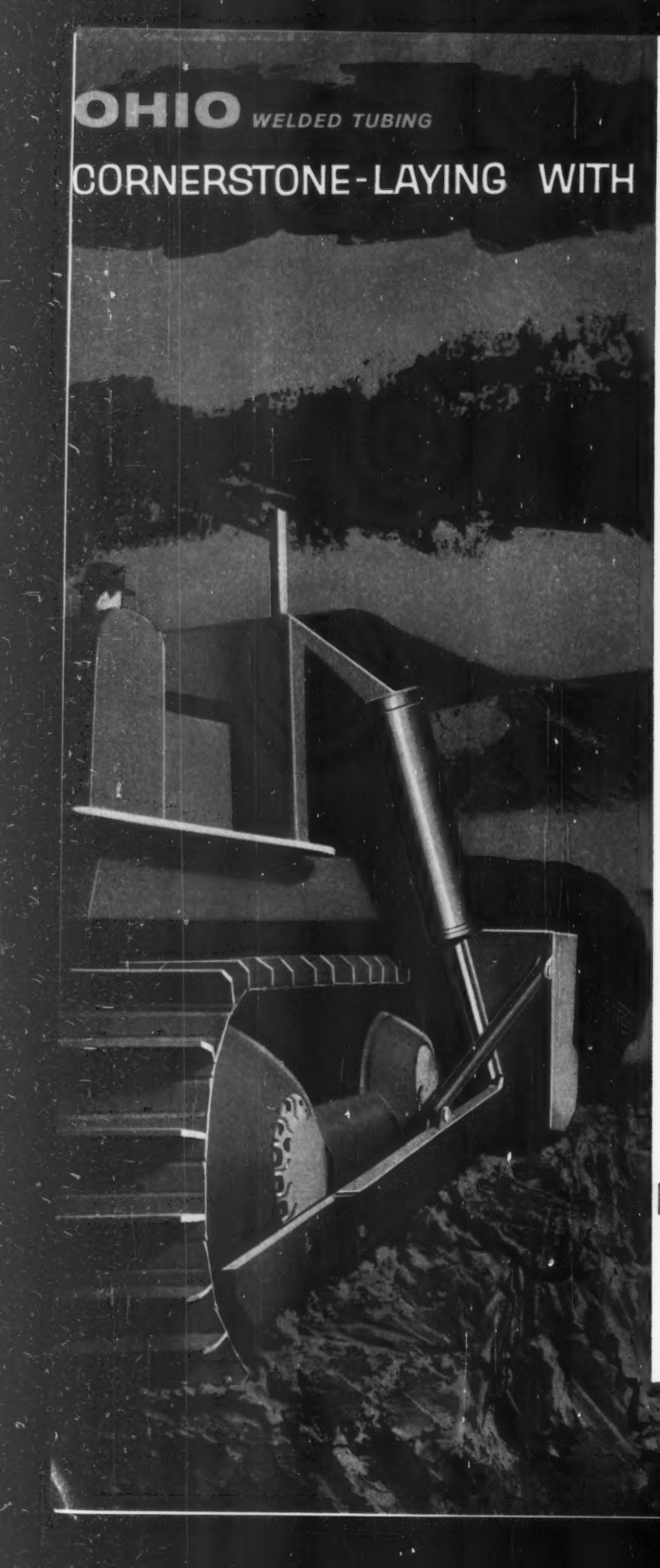
For more complete information, write for 70-page Catalog 5001C.



VICKERS®

VICKERS INCORPORATED
DIVISION OF SPERRY RAND CORPORATION
Machinery Hydraulics Division
ADMINISTRATIVE and ENGINEERING CENTER
Department 1430 • Detroit 32, Michigan

9139



OHIO WELDED TUBING

CORNERSTONE-LAYING WITH

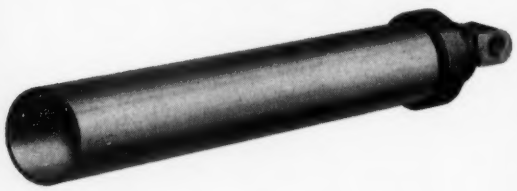
NO CEREMONY

In today's hustling, bustling construction business there's no time to stand on ceremony . . . no point in risking costly equipment failure.

To short-circuit mechanical downtime, leading construction equipment producers specify Ohio Tubing for power cylinders and fluid lines, mechanical and structural members. This gives equipment the heft and brawn to shrug off brutal, grinding punishment . . . gives equipment users a high degree of protection against disastrous delays.

You can strengthen your product — and its mechanical reputation — by specifying Ohio *Custom Made* Tubing. The name Ohio is the hallmark of the highest quality in tubing, both seamless and welded. And we're now able to deliver a broader range of welded tubing sizes, wall thicknesses and grades than ever before.

Let's not stand on ceremony. We want your tubing business — seamless to 7" OD, *welded up to 7½" OD.* For a fast start, contact your nearest Ohio representative, or send part drawings to the plant at *Shelby, Ohio—Birthplace of the Seamless Steel Tube Industry In America.*



Ohio Seamless offers the broadest parallel range of both welded and seamless quality steel tubing in the industry.

OHIO SEAMLESS TUBE

Division of Copperweld Steel Company • **SHELBY, OHIO**

Seamless and Electric Resistance Welded Steel Tubing • Fabricating and Forging

Representatives in principal cities. Check leading directories: THOMAS', MacRAE'S, CONOVER-MAST, SWEET'S, FRASER'S.

Circle 454 on Page 19

A-3305A

EXCLUSIVE from K&E

the Complete Line on Polyester Film

and every film with "engineered" drafting surface

Only K&E offers you all the film-based media for your drafting and reproduction needs, and they're all *working* products, designed to permit additions or deletions. The same engineered drafting surface throughout enables you to standardize on drafting techniques, and the same base throughout means constant behavior characteristics under exposure to light, heat, moisture, etc.

1. HERCULENE® – the unchallenged leader among drafting films, with better than ever working properties for pencil, ink, and typing. Now with a choice of specialized writing mates: *Duralar* plastic pencils render tracings that are completely washable in soap and water . . . new *Ruwe* pencils have all the fine "feel" of graphite, yet resist smudging better than graphite on regular paper.

2. PHOTACT® – the photographic second original *on film* that can be processed with regular *paper* developer. Image lines can be *manually* erased, too (no eradicators needed). Underneath – an excellent drafting surface for changes or additions in pencil, ink or typing. Available in three film types: Contact, Direct Positive, and Projection.

3. DUPRO® – for ink-like second originals that can serve as working copies. Image lines are smudge-proof, with appearance and permanence of photography, yet are easily removed with soft vinyl eraser. For additions or changes in pencil, ink or typing: a perfectly balanced drafting surface underneath. Another advantage: wash-off emulsion permits processing in room light – *no darkroom needed.*

4. HELIOS® – for intermediates of exceptional ruggedness, produced easily, quickly, and at *low cost* by the standard dry diazo process. Mechanical erasure removes image lines (no eradicators needed); engineered drafting surface on the reverse side. Unsurpassed line density and background clarity – black line or sepia.

5. STABILENE® – the *re-stabilized* drafting medium with unsurpassed dimensional stability. Ideal for highly precise work, like the preparation of multi-color maps, printed circuitry, lofting layouts, tools and templates, etc. Available with more than 20 types of surfaces – for pencil and ink work, scribing, peeling, stripping, and a variety of reproduction methods.

For more information on any of these popular K&E polyester-base films, simply mail the coupon below.

KEUFFEL & ESSER CO.

NEW YORK • HOBOKEN, N. J. • DETROIT • CHICAGO
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KEUFFEL & ESSER CO., Dept. MD-2, Hoboken, N. J.

Gentlemen:
Please send me your new brochure titled "Complete Line on Polyester Film."

Name & Title: _____

Company & Address: _____

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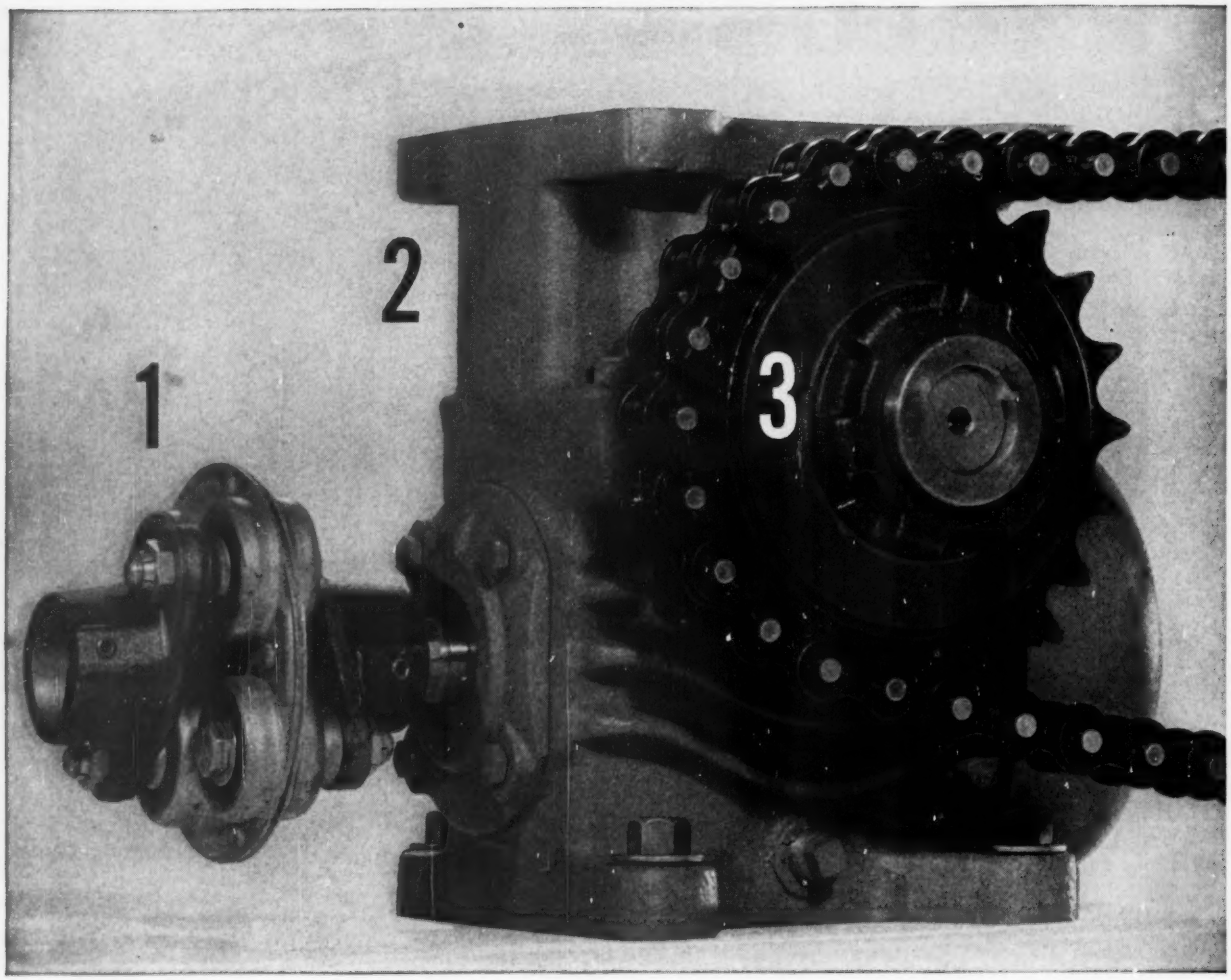
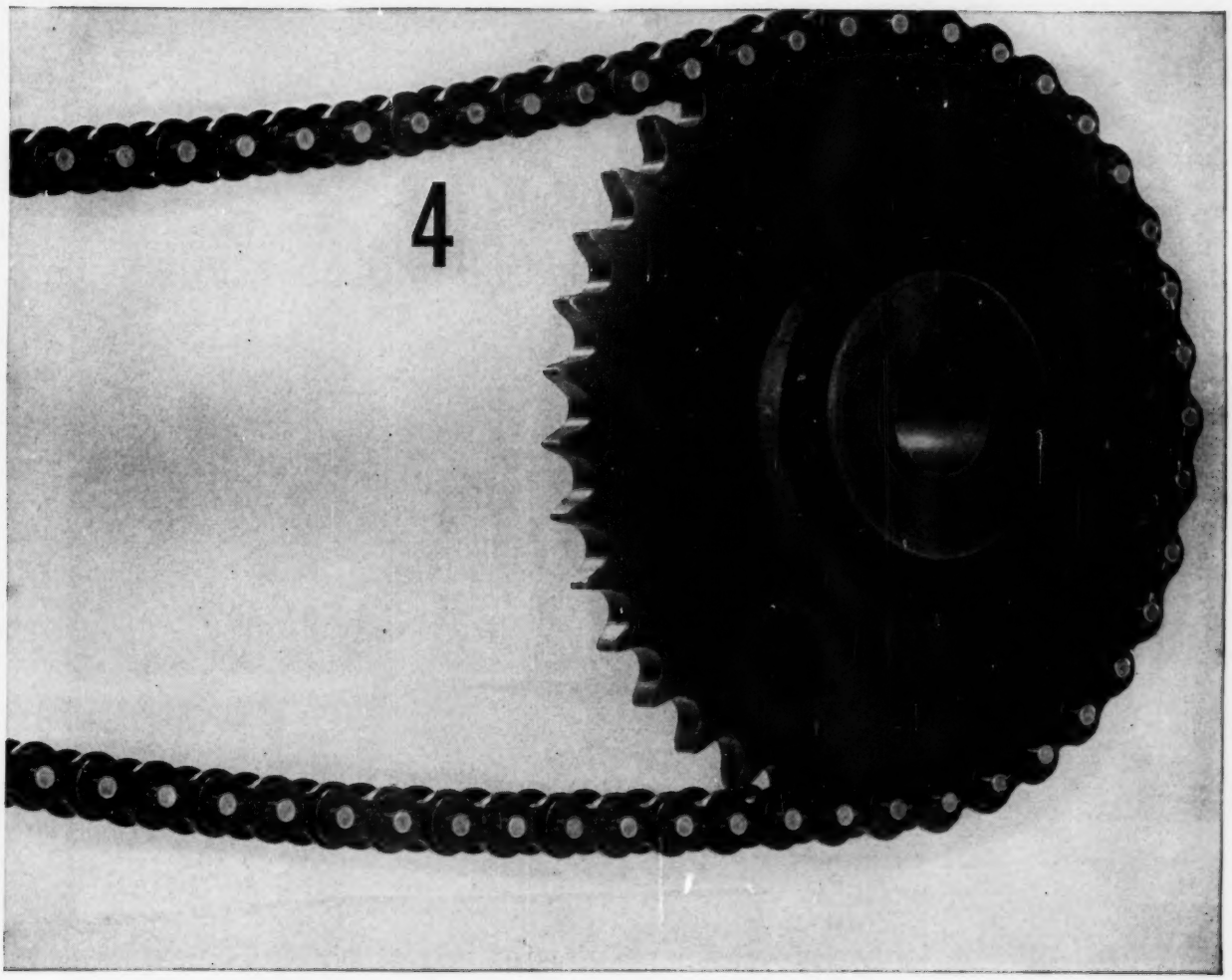


Nobody can service your as completely as Morse, all four of these power

1 Couplings and Driveshafts	2 Eberhardt-Denver Speed Reducers	3 Clutches	4 Chain and "Timing" Belt Drives
Morflex	PoweRgear®	Torque Limiter	Roller Chain
Flexible Chain	Worm Gear	Cam	Silent Chain
Radial	Helical	Overcenter	Hy-Vo® Drives
Nylon	Gearmotors	Pullmore	"Timing"® Belt



power transmission needs because only Morse offers transmission components

REMEMBER: The toughest jobs in power transmission come to Morse, because *only Morse* offers one-source service on all four of these basic components . . . and backs them up with technical know-how based on over 60 years' experience solving power transmission problems.

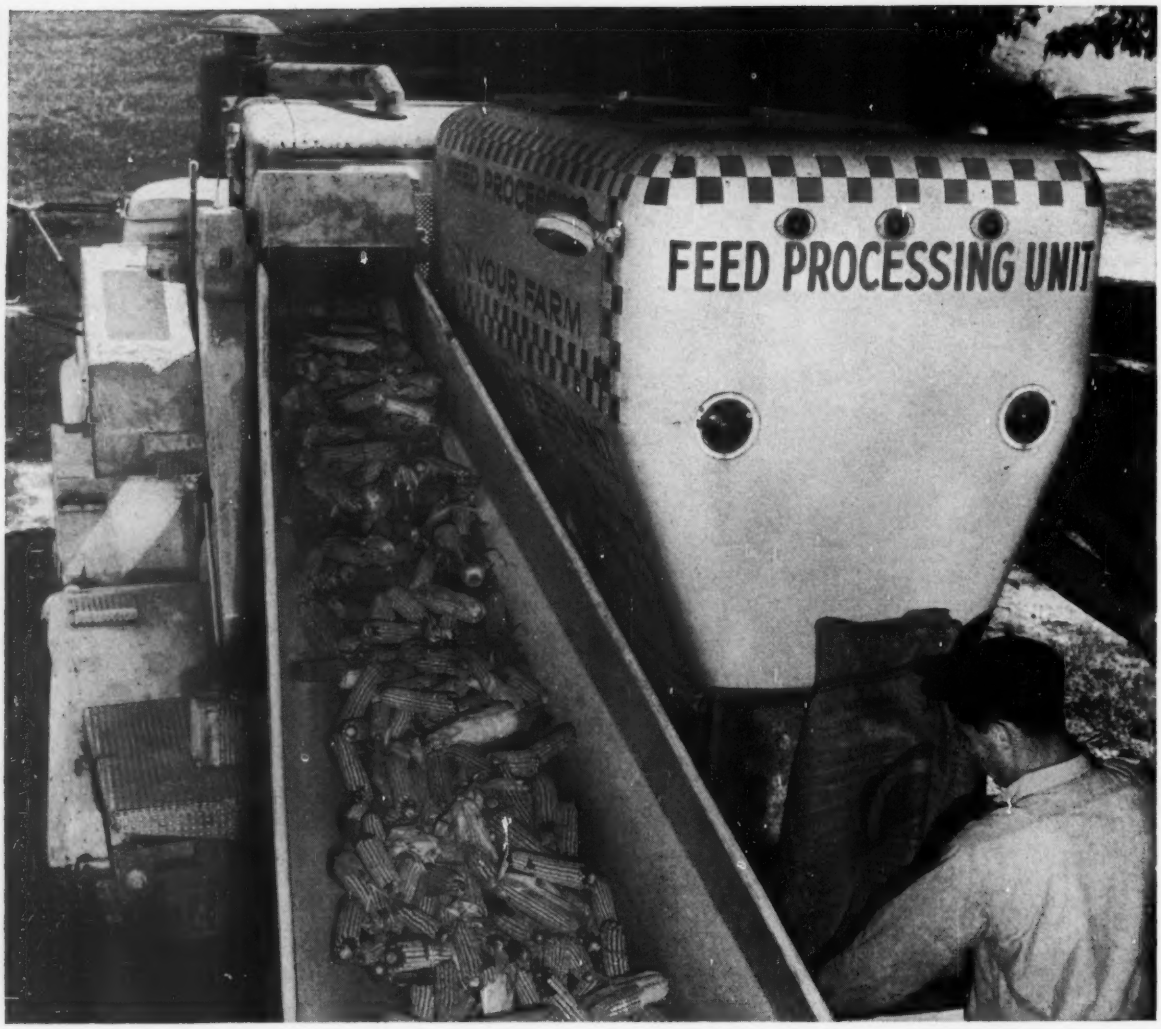
MORSE

A BORG-WARNER INDUSTRY

BW

Look for your local Morse distributor in the Yellow Pages under "Power Transmissions", or write:
MORSE CHAIN COMPANY, Dept. 6-21, ITHACA, NEW YORK. Export Sales: Borg-Warner International, Chicago 3, Ill. In Canada: Morse Chain of Canada, Ltd., Simcoe, Ontario

Circle 456 on Page 19



Made by Daffin Mfg. Co., Lancaster, Pa., feedmobiles save many hours of valuable farm labor in processing 6,500,000 tons of feed annually, and sheet steel provides the strength and dependability that are so necessary in agricultural equipment.

Only sheets of steel could stand this tough grind

Steel
For strength
. . . economy
. . . versatility

Today the crossroads feed mill is a traveling salesman. The Daffin Feedmobile moves right onto the farm, grinds the farmer's own grains and roughages, blends in the minerals and concentrates he needs, and even loads the finished feed just where he wants it—in bins, self-feeders, bags.

Traveling up to 15,000 miles per year, a busy Daffin Feedmobile averages about 15 batches of 3,000 lb each, every working day. That's a tough grind that's made to order for sheet steel. Bethlehem sheets are used in the business end of Daffin's mobile feed mills, providing plenty of strength and rugged dependability.

If you work with steel sheets—hot-rolled, cold-rolled, or galvanized—you can always count on Bethlehem sheets for completely dependable performance. Our engineers will be glad to discuss your sheet-steelworking problems with you.

BETHLEHEM STEEL COMPANY, Bethlehem, Pa.
Export Sales: Bethlehem Steel Export Corporation

BETHLEHEM STEEL

BETHLEHEM STEEL

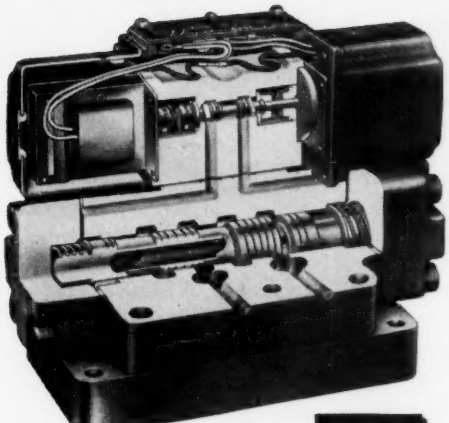
Circle 457 on Page 19

Denison and Denison HydrOILics are registered trademarks of Denison Eng. Div., ABSCO

DENISON HydrOILics

Why you get smoother, more efficient directional hydraulic control with compact new **DENISON**...

4-WAY VALVES



WRITE FOR BULLETIN 220– *"Hydraulic Power to 5000 psi". Fully illustrated, gives complete specifications and application data for Denison's full line of hydraulic pumps, motors, valves and controls.*

Save space, time and cost on exacting directional hydraulic applications. You can apply shockless, positive directional control to any hydraulic circuit—*by specifying Denison 4-Way Valves.* Pilot-operated and solenoid-controlled for systems up to 5000 psi, these service-proved valves offer important features for reliability and design versatility—

Shorter solenoid power stroke permits shorter over-all valve length to speed response. Denison valves deliver fast, rapid-cycle control of flows of 30 gpm at 20 feet-per-second.

Drawn steel solenoid covers are secured to body with internal retaining cords. No bulky chains.

Built-in check valve provides pilot pressure without addition of another valve to the system.

Adjustable pilot chokes assure smooth valving action.

Wide choice of spool types and positioning allows handling an unlimited range of applications.

Denison 4-Way Valves also feature large capacity porting • ample wiring space • interchangeable parts • built to JIC standards.

Contact your nearby Denison hydraulic field specialist for details, or write direct to—

DENISON ENGINEERING DIVISION
American Brake Shoe Company
1240 Dublin Road • Columbus 16, Ohio

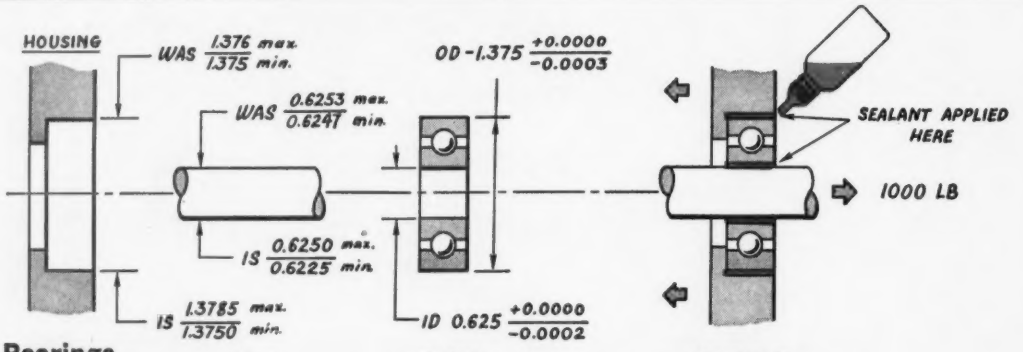
HYDRAULIC PRESSES
PUMPS • MOTORS • CONTROLS

DENISON
HYDRAULIC MULTIPRESS

Circle 458 on Page 19

SIMPLIFY ASSEMBLY...
Retain parts on shafts with slip fit and Loctite

Designing with liquid LOCTITE eliminates press fits, shrink fits, broaching, knurling, keyways, set screws and pinning ... provides easier tolerances ... cuts rejects and rework.

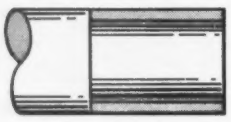


Bearings

LOCTITE Sealant replaced press fit, opening up tolerances .002 inch on shaft and housing. Rejects were cut from 8% to 1% and rework from 20% to 0! Bond to inner race withstands 1000 lbs. thrust ... equal to the best press fit. Slip fit with LOCTITE gives more uniform retention ... eliminates fretting damage due to loose "press fit" or bearing distortion resulting from tight press fit ... assures better shaft alignment. Easier tolerances speed assembly.

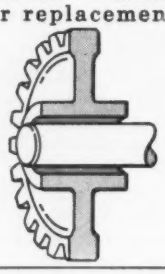
Hardened Sleeves

Eliminates shrink fit ... mounts hardened sleeve without pulling temper.



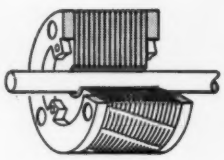
Gears and Pulleys

Eliminates broaching, knurling, shaft distortion. Easier gear replacement.



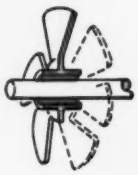
Rotors

Eliminates shaft distortion and resulting regrinding & straightening.



Fans

Eliminates set screws ... no amount of vibration will loosen part.



LOCTITE Sealant is easy to apply... simple to automate

LOCTITE is a one-component liquid with the unique property of converting to a tough plastic when confined between close fitting metal parts. It does not air dry. It does not require mixing with a catalyst and will not spoil on standing in a storage vessel. It comes fully prepared ... stores for years ... hardens only when treated parts are assembled. It forms a tough seal that resists heat, oil, water, all common solvents. Parts treated with LOCTITE can be disassembled by ordinary methods.

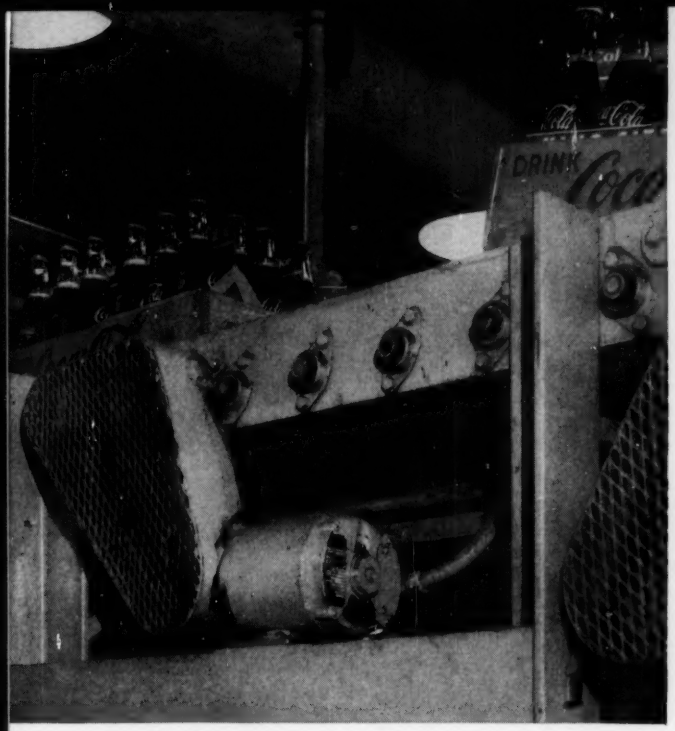
LOCTITE Kit No. 10-10

Contains 10 grades of Loctite Sealant specially put up to assist designers in determining proper grade and use of Loctite in product development and for general experimental work. By selection of proper grade, the designer can apply a predetermined amount of locking torque.

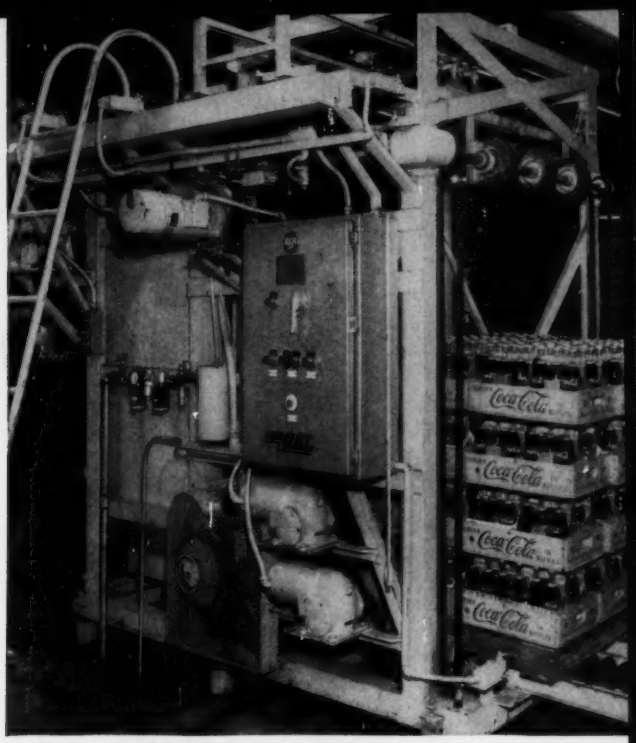
Write for literature and free sample capsule.

LOCTITE® SEALANT

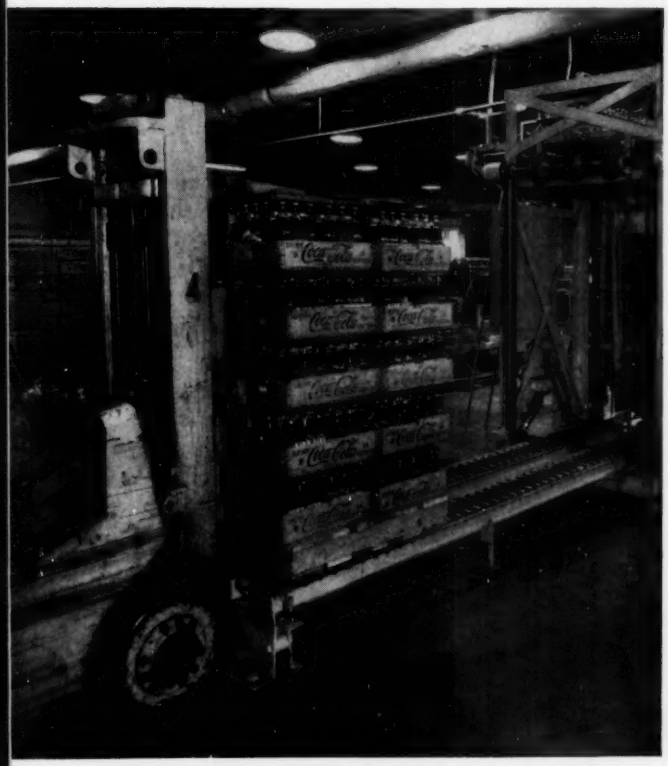
AMERICAN SEALANTS CO. 111 North Mountain Road, Hartford 11, Conn.



1 Century's compact IR 48-frame gearmotor driving live roll conveyor to the top of pallet loader.



2 A Century 1R64 SC64 gearmotor with brake (in upper left of picture) raises and lowers pallets from empty pallet conveyor to loaded pallet conveyor.



3 Loaded pallets being picked up by lift truck. Century 1R66 SC66, ¾ horsepower gearmotors drive empty and loaded pallet conveyors.

Century gearmotors load, stack and convey thousands of soft drinks per day

Century Electric's single-reduction, right-angle gearmotors are built right into the versatile pallet loader shown here. Thousands of bottles of soft drinks a day are conveyed, stacked, loaded onto pallets and conveyed to fork lift trucks by Century's gearmotors.

Century gearmotors, with silicon bronze worm gears and hardened high-grade steel worms, are designed and built to withstand sudden shocks and overloads in applications such as this pallet loader. Motor shafts are not affected by operational strains because mounting feet are an integral part of the housing (except the IR 48-frame). Also, motor shafts are carried on ball bearings and output shafts run in tapered roller bearings to withstand sudden shocks.

All-angle oiling design assures complete lubrication. Worms or worm gears dip into oil, no matter how the gearmotors are mounted.

The gearhead on the IR 48-frame gearmotor (Picture No. 1) can be assembled in four different positions in relation to the motor, and the motor can be mounted at any angle. The new 1R 48-frame gearmotor is also very compact. With it you can reduce the weight of your product by as much as 20 pounds.

For more information about Century's complete gearmotor line from ⅛ to 125 horsepower, call your nearest Century Sales Office.

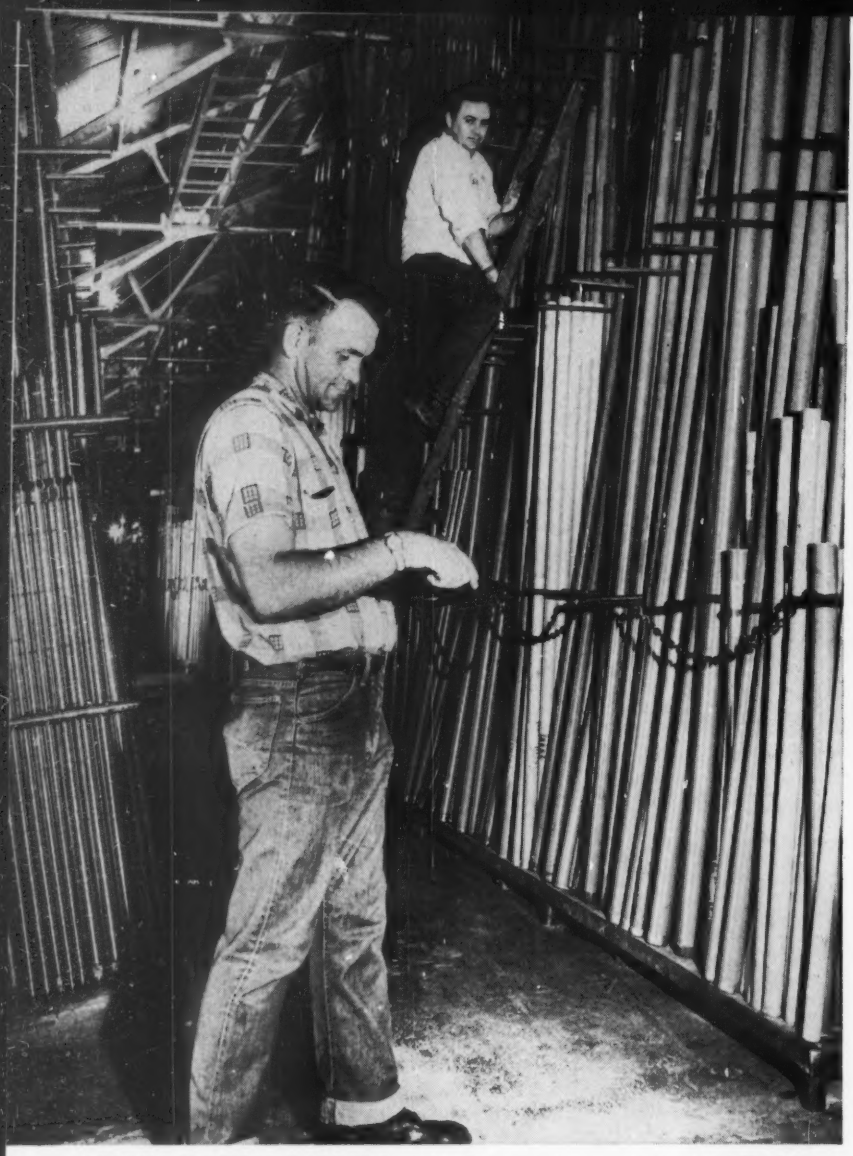
CENTURY ELECTRIC COMPANY

St. Louis 3, Missouri *Offices and Stock Points in Principal Cities*

Circle 460 on Page 19

Century

60-2



SEAMLESS STEEL BARRELS and other pump components of Harbison-Fischer's rod and tubing displacement pumps show great size range required to bring oil to the surface. Pumps vary on I. D. from ¾ inch to 5¾ inches; from 3 to 42 feet in length. Harbison-Fischer counts on commercial quality Pittsburgh Seamless Mechanical Tubing to get a 4 to 6 micro-inch I. D. finish with minimum clean-up expense.

Pittsburgh Seamless Tubes Give a Lift...

WHEN OIL MEN MAN THE PUMPS

When the gusher quits gushing and the oil flow slows to a trickle, it's time for oil men to man the pumps.

Pittsburgh Steel Company helps give them the lift they need with seamless mechanical tubing for sub-surface displacement pumps made by Harbison-Fischer Manufacturing Company of Fort Worth, Texas.

Nine of every ten producing wells must be pumped—and most depend on slender, precision-made rod and tubing pumps for efficient oil production. Harbison-Fischer has supplied them to the oil industry for more than 25 years—"The Best Pumps in the Oil Patch."

Among its eight types and wide range of sizes, there's a Harbison-Fischer pump to match every lifting job and well condition, whether it be depth, heat, pressure, corrosion or abrasion.

Pittsburgh Seamless Mechanical Tubing forms the pump barrel that contains plungers and valves. Besides destructive conditions below surface, barrels often must bear the weight (5 to 6,000 psi) of a fluid column of oil 10,000 feet or more deep.

● **Tight Specs**—To meet rigid API standards as well as its own manufacturing needs, Harbison-Fischer requires mechanical tubing with exact chemical and physical properties, and close tolerance I. D. and wall dimensions.

It demands tubing that is exceptionally straight, free of seams, laps and pits; made of steel that is machinable, and—in the high carbon range—fine grained and hardenable.

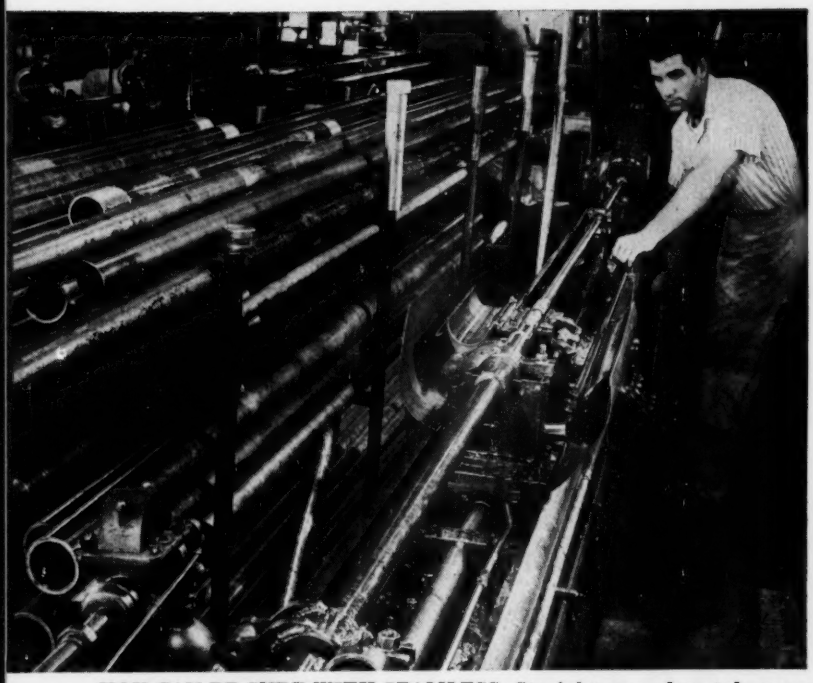
Pittsburgh Steel answers these requirements with mechanical tubing in C-1015 and C-1040 grades in commercial quality to help Harbison-Fischer hold processing to a minimum.

● **Fine I. D. Surface**—In production, Harbison-Fischer wants minimum stock removal to obtain a mirror I. D. finish and extreme straightness.

On its dozen long-stroke hydraulic hones, H-F holds the I. D. stock removal to a few thousandths of an inch. Says Harbison-Fischer:

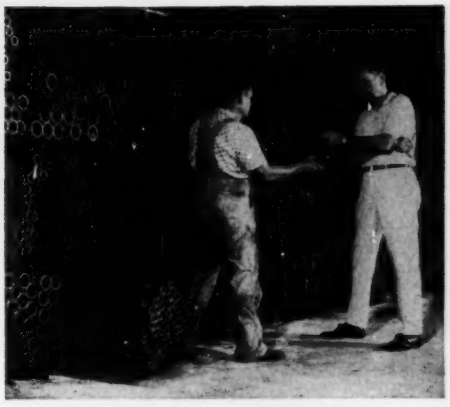
"The honed I. D. must be entirely free of pits. We want a four to six micro-finish. So you can see why the tubing's I. D. mill finish is important."

After threading and honing, every barrel is re-straightened to a tolerance of .015 TIR (total indicator



YOU CAN BE SURE WITH SEAMLESS. Straightness, close tolerance wall thickness and absence of seams, laps and pits in Pittsburgh Seamless Tubing mean fast, easy clean-up on horizontal hones. Minimum stock removal in honing tube's inner surface results in a mirror finish. Six-foot tube being set up here will become working barrel of two-inch tubing pump.

HONED TUBE GETS RIGID INSPECTION. Inspector uses I. D. micrometer to make certain barrel of 3-inch tubing pump stays within tolerance limits of −.0000/ +.0015 inch.



PRODUCTION PERSONNEL check wide variety of tubing used by Harbison-Fischer to produce "Best Pumps in the Oil Patch" for world-wide market.

reading) to overcome distortion caused by working of the tubing.

For installations where hard pumping and hard wear are factors, Harbison-Fischer heat-treats high carbon barrel tubing by an exclusive electronic process. The process penetrates the I. D. a predetermined depth to produce exceptional wearing quality, while permitting the O. D. to remain ductile and shock resistant.

Applications such as Harbison-Fischer's are typical of the uses to which Pittsburgh Seamless Tubing is put. There are thousands of them.

If you manufacture cylindrical products or parts requiring close tolerance, smooth surface or specific physical properties, you can be sure with Pittsburgh Seamless Mechanical Tubing. It can save you time and processing costs. Contact one of the district offices or distributors listed at the right. A Pittsburgh Steel representative will show you how.

Pittsburgh Seamless Distributors

Baker Steel & Tube Company
Los Angeles, California

Chicago Tube & Iron Company
Chicago, Illinois

Cleveland Tool & Supply Co.
Cleveland, Ohio

Drummond, McCall & Co., Ltd.
Montreal, Quebec, Canada

Edgcomb Steel Company
Philadelphia, Pennsylvania

Gilmore Steel Corporation
San Francisco, California

Earle M. Jorgensen Co.

Kilsby-Tubesupply, Division of
Republic Supply Co.
of California
Los Angeles, California

Mapes & Sprowl Steel Co.
Union, New Jersey

Metal Goods Corporation
St. Louis, Missouri

Miller Steel Company, Inc.
Hillside, New Jersey

A. B. Murray Co., Inc.
Elizabeth, New Jersey

C. A. Russell, Inc.
Houston, Texas

Ryerson, Joseph T. & Son, Inc.

Solar Steel Corporation
Cleveland, Ohio

Standard Tube Sales Corp.
Brooklyn, New York

Steel Sales Corporation
Chicago, Illinois

Tubular Sales
Detroit, Michigan

Tubular Service Corp.
Springdale, Pennsylvania

Ward Steel Co.
Boston, Massachusetts

Ward Steel Service Company
Dayton, Ohio

Pittsburgh Steel Company

Grant Building • Pittsburgh 30, Pa.

DISTRICT SALES OFFICES

Atlanta, Chicago, Cleveland, Dayton, Detroit, Houston, Los Angeles, New York, Philadelphia, Pittsburgh, Tulsa, Warren, Ohio

Circle 461 on Page 19

ELIMINATE UNNECESSARY ASSEMBLY COSTS with

Replace improvised units with readily available precision cam followers.

McGILL®

CAMROL® BEARINGS

CF (Cam Follower) SERIES

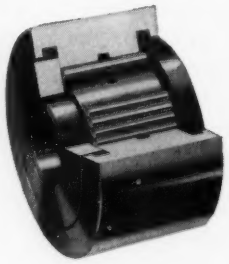
The original and still unsurpassed anti-friction roller bearing cam-follower bearing that adds efficiency at less cost to cam actuated, track and support roller applications. Built with full roller complement and integral stud, the CF series design provides high radial capacity and shock load protection in a compact roller with its own shaft. Easily applied and available in roller diameters of ½" to 4".

for the ultimate in:

- RADIAL CAPACITY
- SHOCK RESISTANCE
- SPACE ECONOMY

SCF SERIES.

Sealed to keep contamination out and lubricant in. It is dimensionally interchangeable with the CF bearings. A turned groove in the center of the outer raceway bore provides a permanent lubricant reservoir to approach life-time lubrication requirements. Can be easily re-lubricated.



SCYR SERIES (sealed)

CYR (Cam Yoke Roller) SERIES

The CYR series increases the adaptability of the CF bearing to all types of automatic machinery involving cam action or controlled-motion machine parts that require guide or support rollers. An inner ring replaces the stud for cam yoke roller mountings.

Write for Catalog No. 52-A for full information on McGill's needle roller bearings, and cam followers. Ask about recommendations for high precision special ball and roller bearings.

SCYR SERIES

This series provides a fully sealed Cam Yoke Roller type bearing. It is dimensionally interchangeable with the CYR bearings.

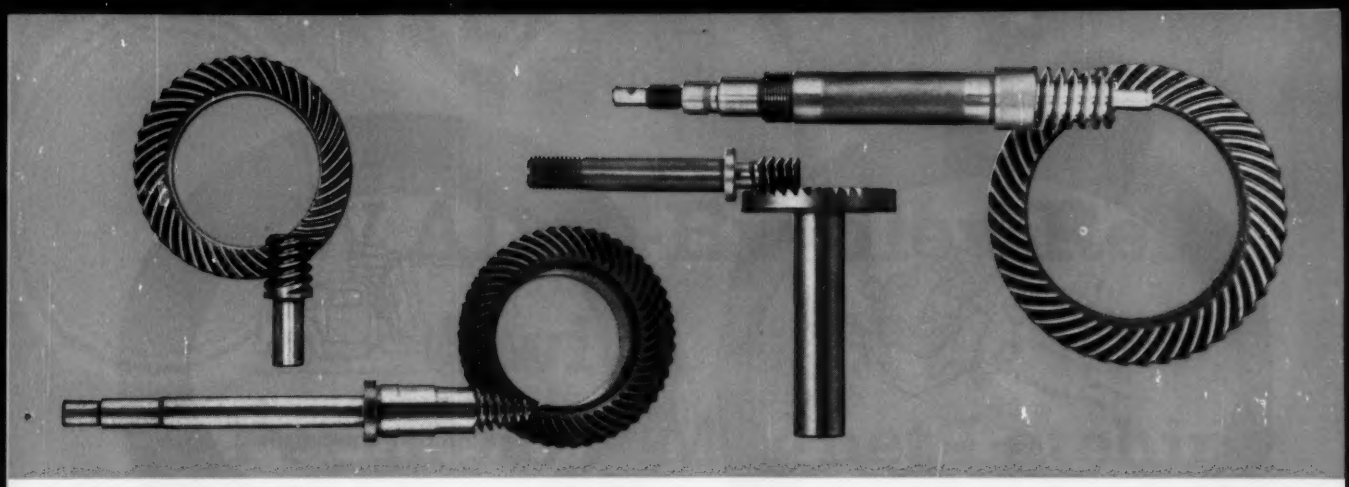
McGILL MANUFACTURING CO., INC., Bearing Division
200 N. Lafayette Street, Valparaiso, Indiana

engineered electrical products

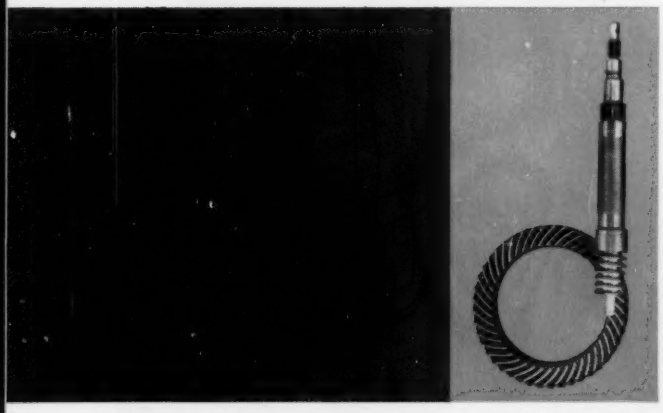
McGILL®

precision needle roller bearings

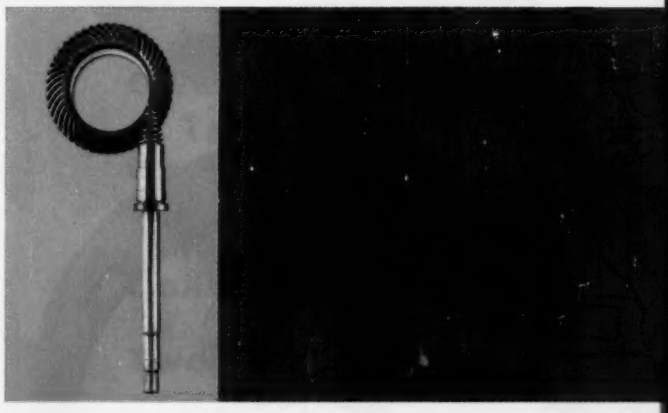
Circle 462 on Page 19



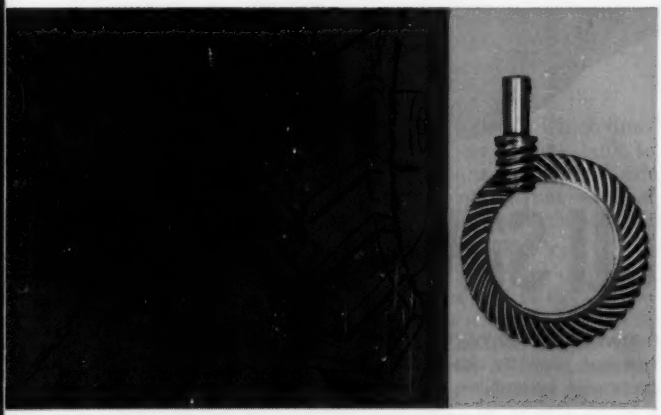
WHICH OF THESE HIGH-RATIO HYPOIDS IS "JUST RIGHT" FOR YOUR PRODUCT?



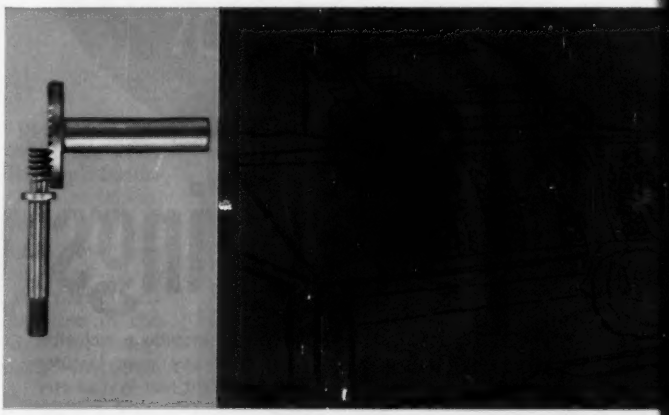
For hand tools. Where space is a problem—as in portable tools like this one—the high offset lets you design a more compact unit. Choose just the offset to solve your design problem with a more flexible, more compact unit than the corresponding worm and wheel.



. . . or machine tools. This high-offset pair lets you combine high reduction with strength, compactness and other advantages you might find profitable in designing machine tools. High-ratio hypoids can be produced on Gleason equipment for ratios of 1:10, 1:40 or even higher.



Big and strong. Where you need strength—as in farm machinery—high-offset hypoid pinions (with teeth which tend to "wrap around") are larger and stronger than corresponding bevel pinions. An extended shank on cylindrical pinions makes very rigid straddle mountings practical.



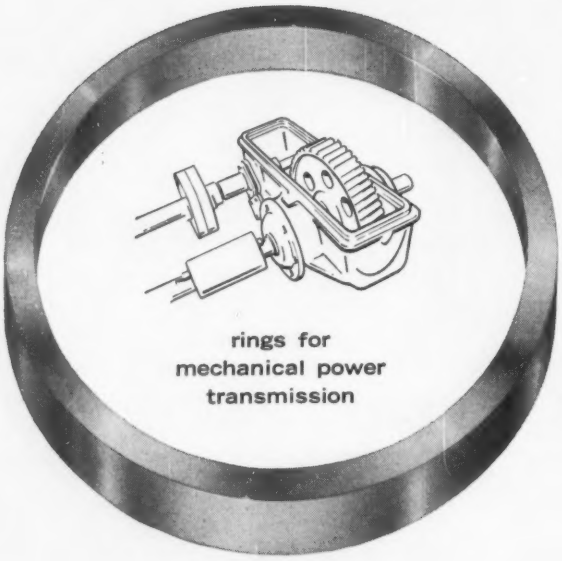
. . . or small and smooth. For smooth operation—as in office equipment that must run quietly—high-offset pairs provide smooth, quiet tooth action. Because teeth "wrap around" the pinion, you get continuous action—even with just one or two teeth! Grinders are available for applications requiring precision finish.

High-offset or high-ratio hypoids can be cut, tested, and quenched on the same Gleason equipment that is used on more familiar spiral bevel and hypoid gears. You can get more information about Gleason high-ratio hypoid gears by writing for free literature. Submit your prints for recommendations.

GLEASON WORKS

1000 UNIVERSITY AVE., ROCHESTER 3, N.Y.

Circle 463 on Page 19



rings for
mechanical power
transmission

rings for
construction equipment
and machinery

rings for
fabricated metal
plate work

rings for
jet aircraft engines
and missiles

we make rings-you save money

Amweld flash butt-welded rings provide a welcome cost reduction opportunity for almost any manufacturer using rings of between four inches and eight feet in diameter from most of the common and exotic alloy metals. Amweld rings save on material because rings are formed closer to finished dimensions. Amweld rings save on machining, because the metal is left out—not hogged out.

Amweld customers saved over one million dollars last year. By close cost evaluation of circular components and assemblies, flash welded rings were introduced enabling substantial savings. It doesn't cost you to think on paper with Amweld. Let us quote you for your cost comparison. Write today: The American Welding & Manufacturing Company, 900 Dietz Road, Warren, Ohio.

AMWELD®
INDUSTRIAL PRODUCTS

THE AMERICAN WELDING & MANUFACTURING CO., WARREN, OHIO

Circle 464 on Page 19

Circle 465 on Page 19→

NEW Allen-Bradley Relay with EXCLUSIVE Permanent Magnet Latching

Saves Panel Space

Gives Millions of Trouble Free Operations

Holds Closed Without Coil Current

Two to Six Poles

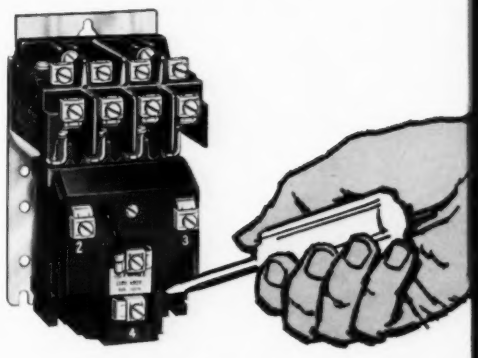
Bulletin 700 TYPE BRM

Here's a completely new "latching" relay—which does not use a mechanical latch! It is the Bulletin 700 Type BRM—built to provide the same millions of dependable operations you get from all Allen-Bradley's industrial relays. A "built-in" permanent magnet eliminates the mechanical latch and the usual troubles caused by mechanical linkages.

When the coil of the new Bulletin 700 Type BRM relay is energized, the relay closes and is held closed after the coil circuit is opened—by a permanent magnet. Energizing the coil in opposition to the permanent magnet field opens the relay. The correct polarity for operation of the relay is obtained from silicon diodes held within the molded coil cover. With no "piggy-back" additions out in front, and no "extra" solenoids below, the Type BRM relay saves valuable panel space.

These A-B Type BRM relays also feature a continuous duty coil that permits the current to be left on, if desired. As with all Allen-Bradley relays, the double break, silver contacts never need attention. And the contacts of these new magnetically latched relays afford the same 60-second convertibility of the popular Bulletin 700 Type BR relay.

For latching relay service, it will pay you to investigate this new and completely different relay. It provides the usual Allen-Bradley quality!



Can be latched or unlatched by hand

ALLEN-BRADLEY

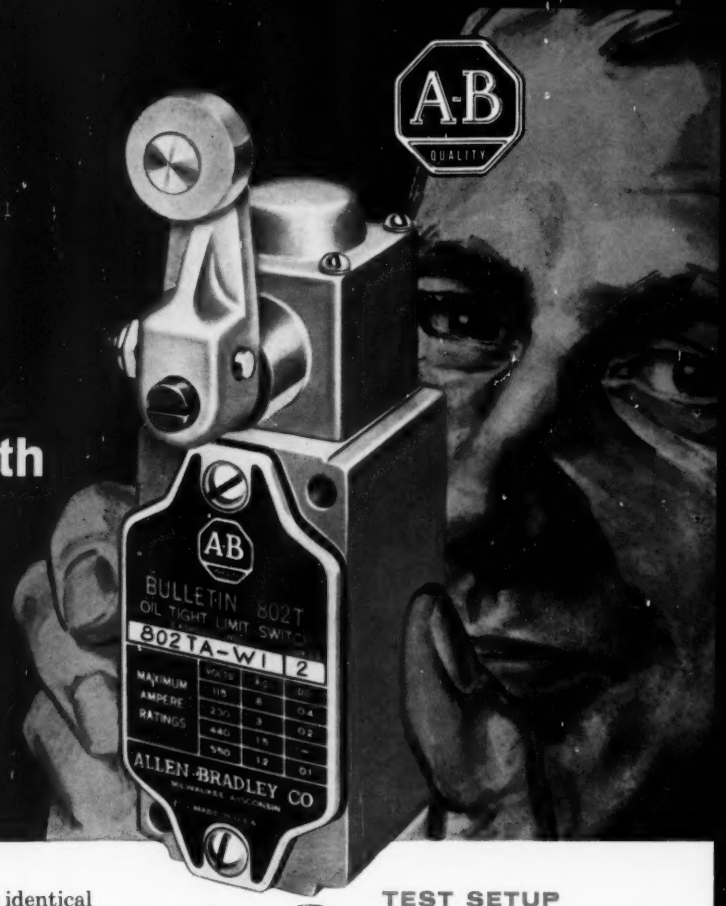
Member of NEMA

Allen-Bradley Co., 1318 S. Second St., Milwaukee 4, Wis. • In Canada: Allen-Bradley Canada Ltd., Galt, Ont.

QUALITY MOTOR CONTROL

Only ALLEN-BRADLEY LIMIT SWITCHES FINISHED TEST with *NO FAILURES!*

... and remained good for many more millions of trouble free operations

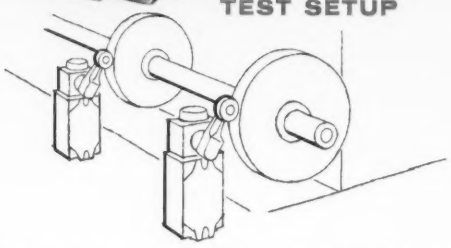


Recently, a large user of limit switches selected two identical units from each of five leading manufacturers and subjected them to the same accelerated life test. When the test was stopped after many, many millions of operations, only Allen-Bradley Bulletin 802T oiltight limit switches were left *with no failures!* Also, a careful inspection of these two Bulletin 802T limit switches suggested that they were still good for *many more millions* of operations.

The Allen-Bradley "built-in" quality is the reason for such unmatched performance. With switch bodies and operating heads positively sealed against oil and dirt, A-B Bulletin 802T limit switches are free from contact fouling and sluggish operation. The precision switch mechanism has a positive snap action—it is impossible for vibration to cause contact chatter. The double break, silver contacts never need servicing.

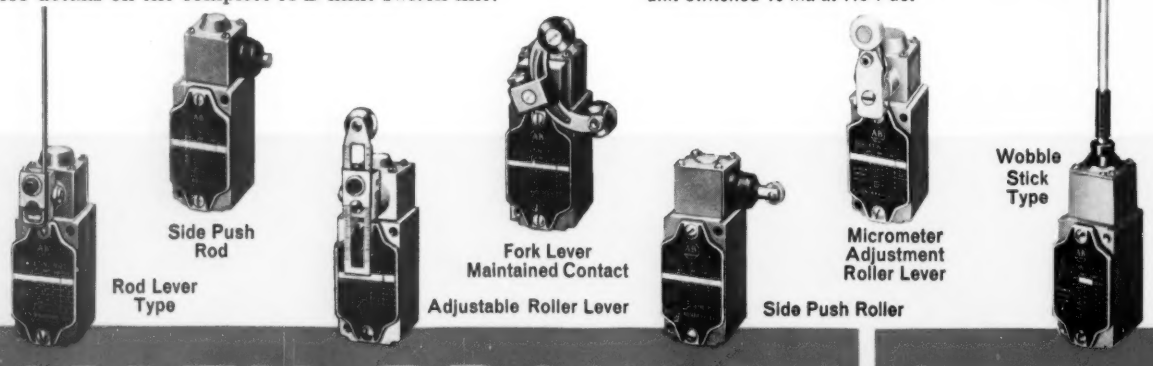
Insist on Allen-Bradley Bulletin 802T oiltight limit switches—they will *always* provide you with the long, trouble free life that is so important to continuous production. Send for details on the complete A-B limit switch line.

TEST SETUP



Purchased through regular supply channels . . .

and tested under identical conditions, insuring an impartial evaluation of performance. Of the ten limit switches tested (two each of five different makes), only three were operating when the test was stopped. Two were A-B Bulletin 802T switches and one of another make, of which the second unit had failed early in the test. On this accelerated life test, one unit switched 1.0 ma at 115 v dc while the other unit switched 10 ma at 115 v dc.



ALLEN-BRADLEY

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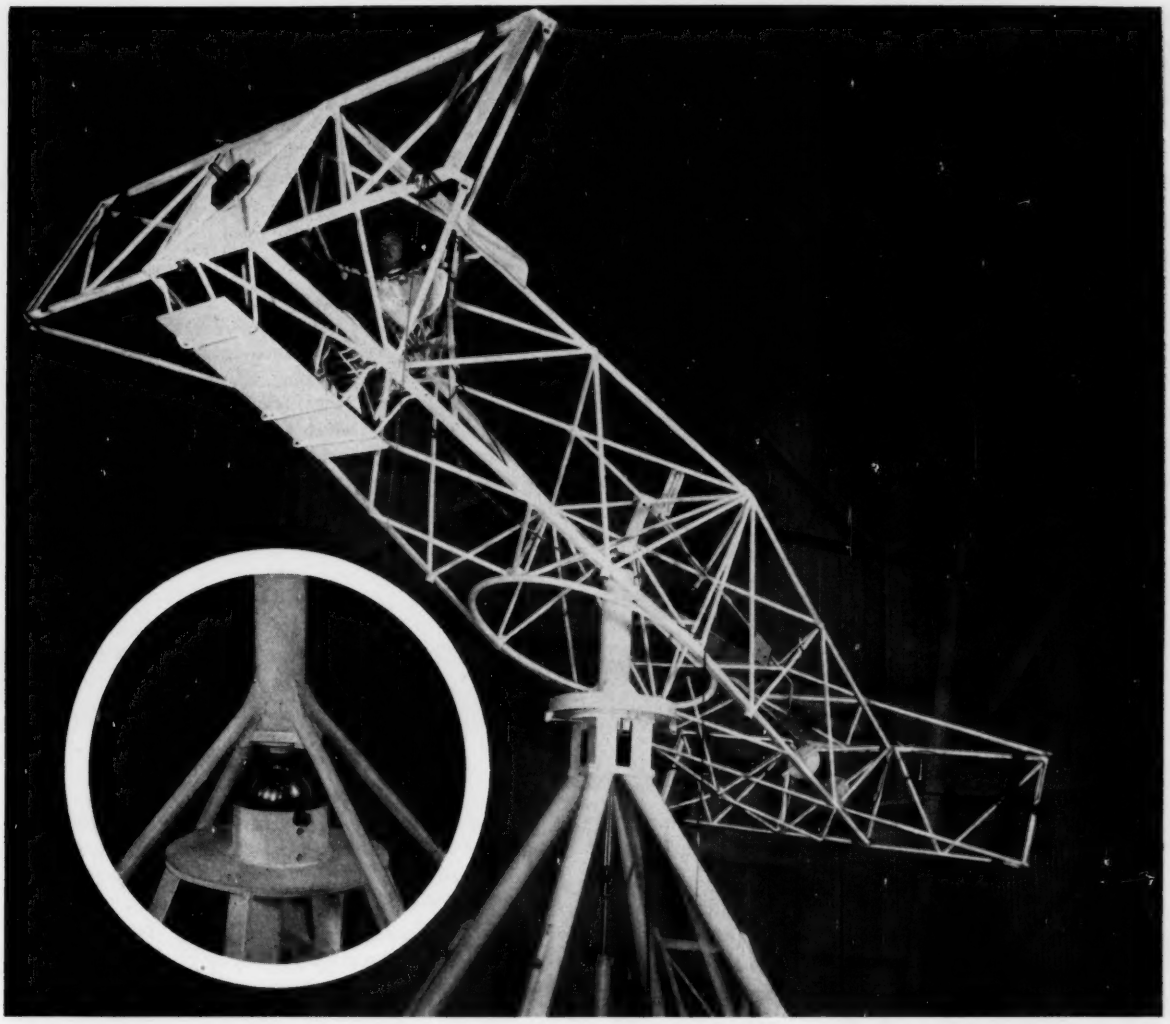
Allen-Bradley Co., 1316 S. Second St., Milwaukee 4, Wis. • In Canada: Allen-Bradley Canada Ltd., Galt, Ont.

QUALITY MOTOR CONTROL



MAKE-BELIEVE FLIGHT—Much of the feeling of flight in a space vehicle is experienced during a ride in this reaction-control simulator, being put through its paces at Boeing Airplane Co., Seattle, Wash. The simulator rides atop the nickel alloy steel ball plated with Nickel in Boeing's ball-and-socket type air bearing.

Space simulator gives the "feel" of flight

Nickel-plated ball of high strength steel supports reaction-control test vehicle

This earthbound space machine is designed to test ways of controlling a vehicle as it pitches, rolls and yaws in the airless reaches of outer space.

In action, the simulator and its payload of test equipment can weigh as much as 5,000 pounds. Yet the necessary sensitivity is achieved by floating the unit on an air-cushion bearing made of a high strength nickel alloy steel ball in its socket.

Imagine this 2½-ton load resting on a ball about the size of a grapefruit! The ball, made of nickel alloy steel heat treated to a tensile strength of 180,000 to 200,000 pounds per square inch, stands up to the load. To provide a hard, smooth surface, the ball is plated with one-thousandth of an inch of Nickel. This uniform surface keeps air leakage in the bearing to a minimum.

Remarkably durable, Nickel and its alloys offer practical solutions to problems of stress, fatigue, abrasion, corrosion or temperature extremes. Used in alloys, in plated coatings or by itself, Nickel helps make possible many new products and processes—and can help improve existing ones—by providing unique combinations of properties.

Can we help you solve a difficult problem in materials? Perhaps you or your engineers can profit from the technical data we have on hand. This information is yours for the asking.

THE INTERNATIONAL NICKEL COMPANY, INC.

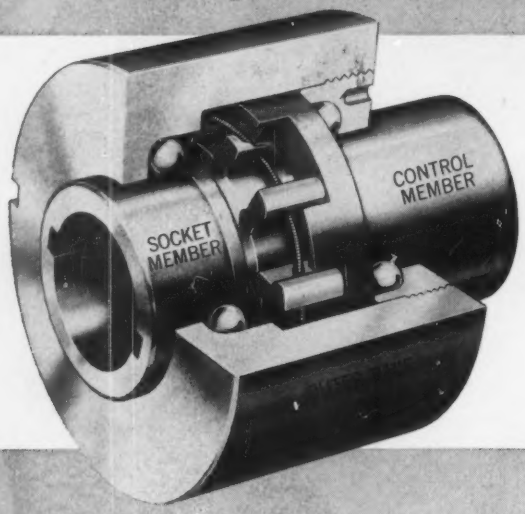
67 Wall Street INCO New York 5, N. Y.

INCO NICKEL

NICKEL MAKES ALLOYS PERFORM BETTER LONGER

←Circle 465 on Page 19

NOW! a positive positioning device that stops feedback torque without backlash . . . .



Rev-Lok devices can efficiently perform a number of application functions such as two-directional drive, positioning, over-running, backstopping, prevention of feedback, etc. Generally, the mounting arrangement used determines which functions are obtained. However, to provide specific details on how Rev-Lok components operate to perform individual functions, sketches and description relating to several typical applications are provided on the facing page.

Now! For any application requiring a power transmission device, that will drive in both directions and instantly stop all feedback torque, the REV-LOK design offers precision performance characteristics and safety factors previously unobtainable in so compact a product.

REV-LOK features a complement of sprags arranged in opposing pairs to automatically and instantly stop feedback in both directions of rotation . . . there is no backlash on output shaft. Also, the design concept provides multi-contact surfaces for greater driving and holding torque, assures equalized radial loading of REV-LOK devices, and evenly distributes wear over all sprags and entire race surface to secure longer life.

The functional versatility of the REV-LOK device is evidenced in its successful use on many diverse applications. Depending on the mounting arrangement employed, REV-LOK devices can be used for: two-directional drive and positive positioning, two-way over-running or backstopping, dual drive or single revolution applications, anti-shock steering, torque limiting, etc.

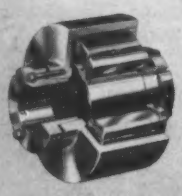
REV-LOK devices have greater torque capacity for their size and weight, and permit higher over-running speeds than any similar product. Current catalog models are available in torque ratings from 90 lbs. in. to 30,000 lbs. in. and with bore diameters ranging from ¼" to 2½". Send for your free REV-LOK catalog—it provides further operational and technical details.

FORMSPRAG COMPANY

23603 Hoover Road, Dept. 115, Warren (Detroit), Michigan

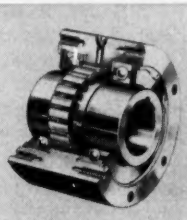
Representation Throughout The World • Precision Power Transmission Products

OTHER FORMSPRAG® PRODUCTS

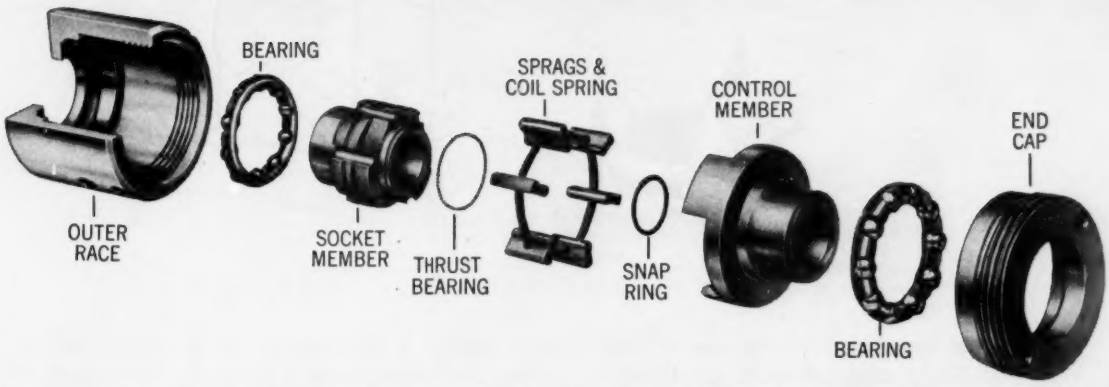


Rawson® Centrifugal Clutches for no-load motor starts and cushioned starting of loads.

Formsprag® Clutches for every over-running, indexing and backstopping application.



....this is REVLOK



HERE'S HOW REVLOK DEVICES FUNCTION

With the OUTER RACE held in a stationary or fixed position, torque is transmitted as follows: (Figure 1) The CONTROL MEMBER projects between each pair of opposing sprags and when driving torque is applied to it, each projection first contacts a sprag at point "A" to disengage the sprag from the OUTER RACE. Then, the CONTROL MEMBER drives against the sprag at point "B" to transmit driving torque directly to the SOCKET MEMBER. (Figure 2) When input torque is reversed, the CONTROL MEMBER rotates a maximum of 3° to release the opposing set of sprags and then again drives the SOCKET MEMBER through point "B" on these sprags. (Figure 3) Any input torque from the SOCKET MEMBER is instantly stopped by the wedging of sprags between the fixed OUTER RACE and the SOCKET MEMBER—feedback torque never reaches the CONTROL MEMBER.

(Figure 4) When the SOCKET MEMBER is held stationary and the CONTROL MEMBER is held in a neutral position between the sprags, any input torque applied to the OUTER RACE is instantly stopped by the wedging of the sprags between OUTER RACE and fixed SOCKET MEMBER. However, by applying a relative torque to the CONTROL MEMBER in one direction (Figure 5), the OUTER RACE can over-run in the opposite direction and will also be backstopped. To reverse the direction of OUTER RACE over-running and backstopping, the torque applied to the CONTROL MEMBER is reversed.

(Figure 6) If the CONTROL MEMBER is held in a fixed position and the SOCKET MEMBER is allowed to float freely on a shaft, the OUTER RACE will over-run in either direction. However, if a torque is applied to the SOCKET MEMBER, the OUTER RACE will only over-run in the direction that the torque is applied and will backstop in the opposite direction.

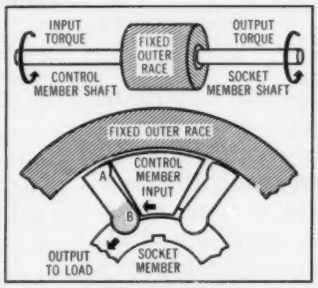


FIGURE 1

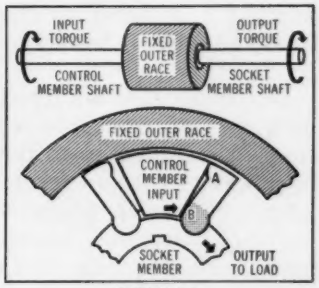


FIGURE 2

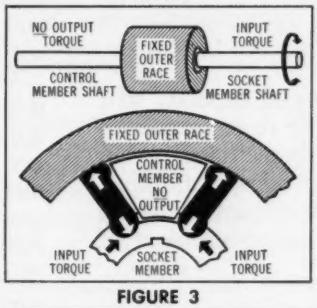


FIGURE 3

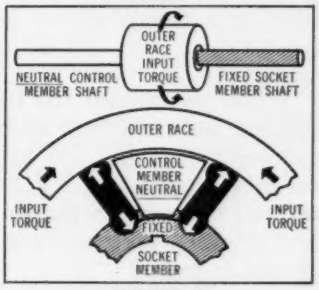


FIGURE 4

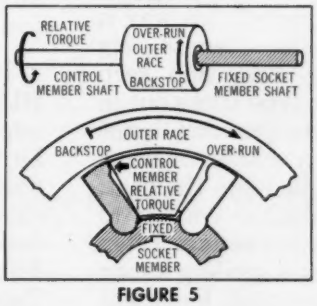


FIGURE 5

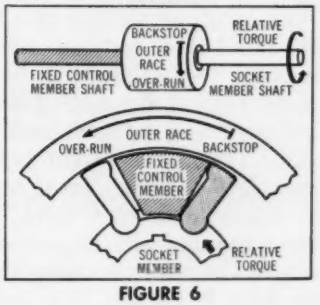
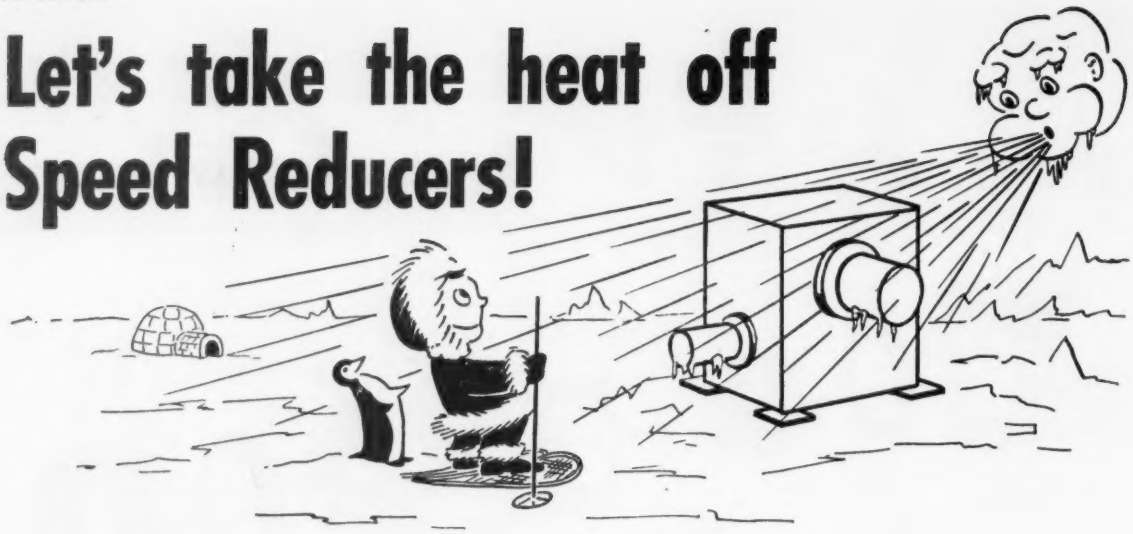


FIGURE 6

(Advertisement)

Let's take the heat off Speed Reducers!



A worm gear speed reducer is one of the toughest little customers in captivity. It reduces speeds day-in, day-out, with little complaint. While it works long and hard, it has limitations—set by ratio, center distance, RPM, mechanical and thermal HP ratings, etc. And, depending upon how precisely it was selected and fitted to the job requirements, it will do what it has to do.

But sometimes it's forced to play outside of its league. It must cope with job requirements that vary from here to there—normal 8 to 10 hour service without recurrent shock, the same length of service where there is some shock loading, continuous low-speed service and almost countless others. But the thing that really puts the pressure on reducers, the thing that's lurking in *every* set of job requirements—is h-e-a-t.

When you exceed the thermal capacity of a reducer for more than an hour or so, excessive temperature thins the lubricant resulting in wear; material, bearing and oil seal failures; etc. Of course, the proper lubricant will help but it can't cure the continuing problem of excessive heat.

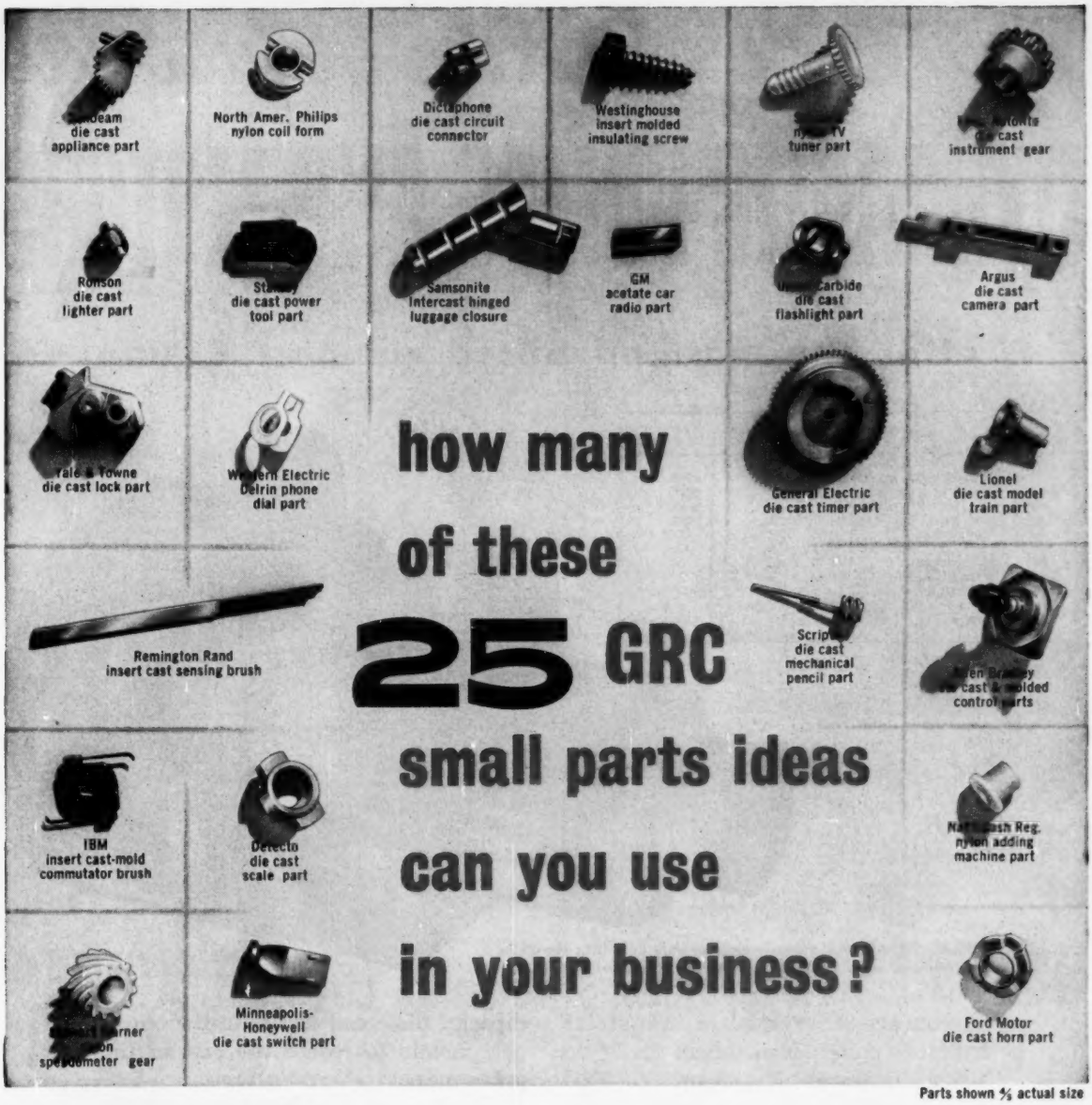
So how can we lick this toughy? One way is to build the reducer housing oversize, big enough to radiate the heat away and keep temperatures down. But this type sticks out in aisles, louses up compact designs and barks shins. Then, we might try a smaller housing complete with fins on it to dissipate the heat. If this still doesn't work, another trick is to use a reducer with capacities and ratings a step above the ones we need. This is sending a man to do a boy's job. It's impractical, inefficient and costly. There *has* to be an easier, better, saner and cheaper way to do it. And there is!

In certain cases, where the size and type of reducer permits and where we can gain enough in thermal HP rating to keep heat generation in bounds, Cone-Drive Gears does it with fan-cooling.

What's that? Simple. Just add a fan to the worm shaft plus the necessary air shields, fan cover, etc., and presto!—heat is no longer a problem. The air shields direct the fan-pushed air over the fins on the lower portion of the reducer. The fins are shaped and spotted to guide the air stream where it is needed. Thermal HP ratings are boosted tremendously, as high as 147% above those of standard reducers in some cases! Those over-worked, over-heated reducers will now do the job you bought them to do.

Other advantages? They're here in abundance. The size of the reducer stays the same. All parts on a Cone-Drive fan-cooled reducer are 100% interchangeable with parts for standard reducers. Oil capacity is identical. Shields are quickly removed without disconnecting the reducer. (This is important where severe operating conditions make periodic cleaning necessary). The reducer can also be operated *without* fan-cooling just by taking off the fan and shields.

This simple addition to standard Cone-Drive HU speed reducers might be just your answer—might save you some money. Write for Cone-Drive's Bulletin CD-218. It will tell you all about the full line of Cone-Drive double-enveloping worm gear reducers as well as the fan-cooled kind. Cone-Drive Gears, Div. Michigan Tool Co., 7171 E. McNichols Rd., Detroit 12, Mich.


Dictaphone die cast circuit connector
Westinghouse insert molded insulating screw
Ronson die cast lighter part
Samsonite Intercast hinged luggage closure
GM acetate car radio part
Argus die cast camera part
Yale & Towne die cast lock part
Western Electric Delrin phone dial part
General Electric die cast timer part
Lionel die cast model train part
Remington Rand insert cast sensing brush
IBM insert cast-mold commutator brush
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small parts ideas
can you use
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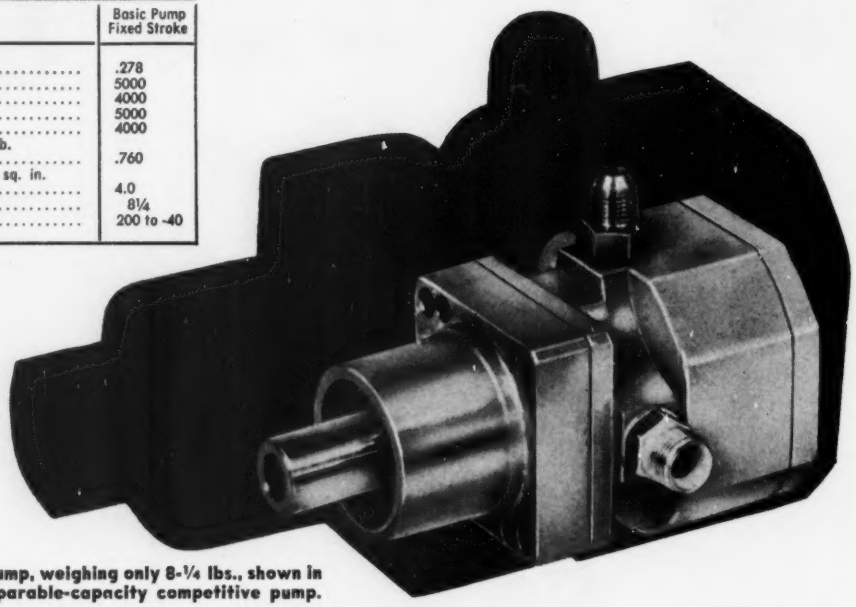
Nominal speed (peak)	5000
(r.p.m.) (continuous)	4000
Input h.p. at 1,000 r.p.m. and 1,000 lb. per sq. in. differential	.760
Max. Torque (lb./ft.) per 1,000 lb. per sq. in. fluid pressure differential	4.0
Weight (lb.) Basic Pump	8¼
Operating temperature, ° F	200 to -40



LUCAS-ROTAX IA4 pump, weighing only 8-¼ lbs., shown in comparison with comparable-capacity competitive pump.

If you are interested in industrial hydraulic pumps or motors in the 1.5 to 108 g.p.m. range at pressures to 5000 p.s.i., you'll find more good design features in Lucas-Rotax pumps and motors than in any other quality line.

Lucas-Rotax industrial hydraulic pumps and motors are smaller and lighter than conventional units with low noise level in spite of high operating speeds. They offer fast response rate in pressure compensation and the low and medium capacity units can be operated from 2-pole motors to reduce the cost of the prime mover.

Pumps are available as variable volume, variable volume pressure compensated, overcentre cam (reversible) or fixed volume. Motors can be supplied in variable or fixed volume. Both pumps and motors deliver high performance with minimum maintenance. Available in quantity from domestic stock—call or write for technical data.

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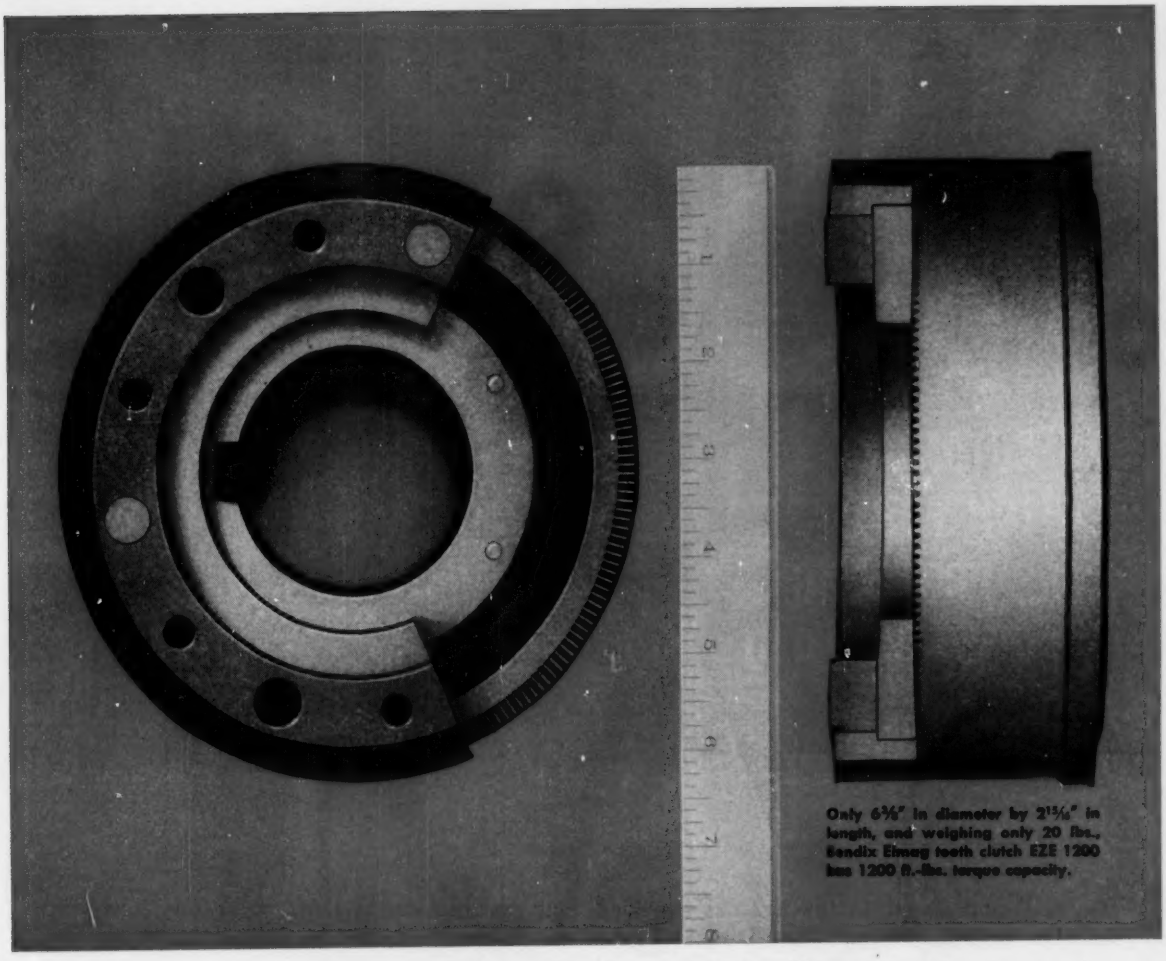


Only 6⅜" in diameter by 2¹³⁄₁₆" in length, and weighing only 20 lbs., Bendix Elmag tooth clutch EZE 1200 has 1200 ft.-lbs. torque capacity.

Designed for more torque in less space

BENDIX ELMAG* *(Electromagnetic)* TOOTH CLUTCH

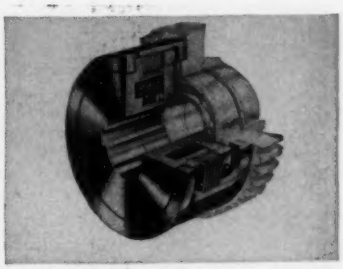
Machine designers now can provide for greater machine capacity, or space savings—or both—with the Bendix Elmag tooth clutch. This small, efficient package offers greater torque transmittal than is provided by other clutches of the same size.

It is more positive and simpler in design (only 3 parts) than other kinds of clutches. There is absolutely no idle torque—no connection between driving and driven members once disengaged. The Elmag can be disengaged under full load at any RPM, and engagement at relative speed is possible. The clutch's simple, bolt-on design makes it easy to mount; there are no additional splines or springs, no external disengagement mechanism.

*TRADEMARK

Elmag tooth clutches are designed to perform in either wet or dry applications. They are available from stock in torque capacities ranging from 40 to 4,000 ft.-lbs.

BENDIX ELMAG MULTIPLE DISC CLUTCH—Ideal for step-by-step acceleration of large masses. Disc stack is magnetically isolated. Wet or dry operation. Slip ring or stationary field design. Torque capacities: 10 to 16,000 ft.-lbs.



For full details, write

Bendix-Elmira
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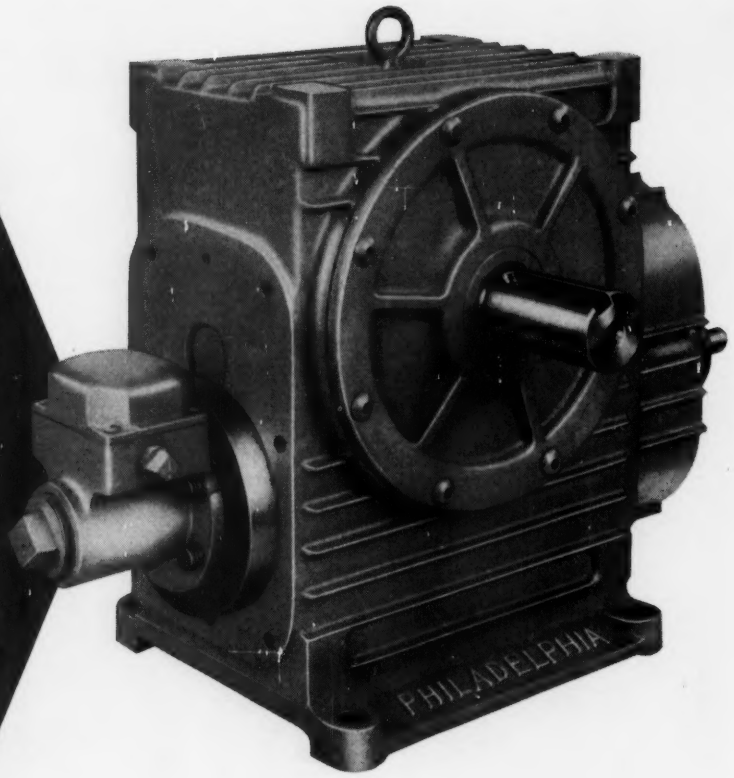
THE Bendix CORPORATION

INSIDE!

AN AUTOMATIC SWITCH FOR FAST, SURE PROTECTION AGAINST OVERLOAD

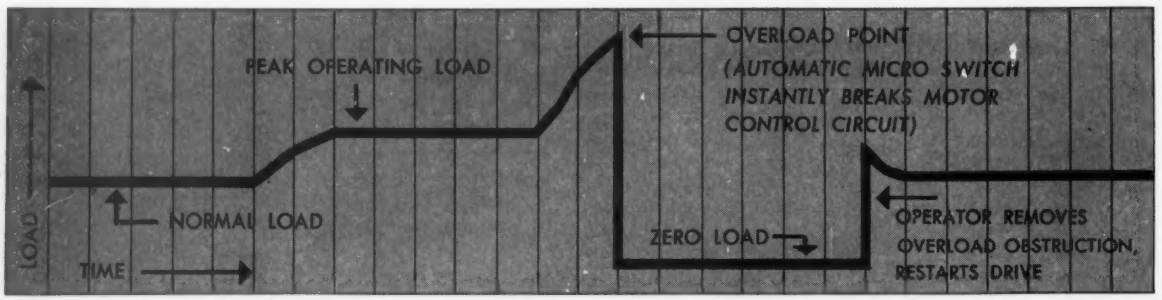


Here is instant protection against overload damage . . . Philadelphia Gear's Torque Control for worm gear reducers. When output torque of the reducer exceeds a pre-set value, the control breaks the motor control circuit—instantly. This is accomplished by mechanical actuation of an electrical line break switch. Truly foolproof protection for driving and driven equipment.

Time saved with Torque Control can be considerable, too. For example, you can remove the cause of overload or jam immediately. There is no waiting for heaters to function or for shear pin replacement. In short, downtime is either drastically cut or eliminated.

How about starting surge? Here, too, is an advantage . . . the control can be by-passed by holding the START push button to permit this temporary overload. Torque Control is optional on Phillie Gear equipment, and is available for either one direction of operation or both.

For information on our complete line of Worm Gear Reducers, write for catalog WG-60.



philadelphia gear drives

PHILADELPHIA GEAR CORPORATION

King of Prussia (Suburban Philadelphia), Pennsylvania

Circle 472 on Page 19

Think Profit . . .

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HOLO-KROME THERMO-FORGED* SOCKET SCREWS HELP INCREASE PROFITS BY REDUCING INSPECTION REJECT AND IN-WARRANTY SERVICE COSTS

Join other profit-conscious industrial leaders in taking a long, hard look at the profit-eating costs of inspection rejects and in-warranty service. You'll see why they're turning to *quality*—in materials and components—to reduce costs and increase profit.

Holo-Krome's exclusive THERMO-FORGED process produces socket screws of unmatched uniformity and quality . . . virtually free from flaws and hidden imperfections. Next time you order socket screws, think of *final* cost *first.* A few extra pennies spent on *quality* will save many hundreds of profit dollars by reducing the high cost of inferior fasteners.

Like full details on how Holo-Krome quality can help increase your profit? See your authorized Holo-Krome distributor, or write for more information.

**Trade Mark of The Holo-Krome Screw Corporation*

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SOCKET SCREWS

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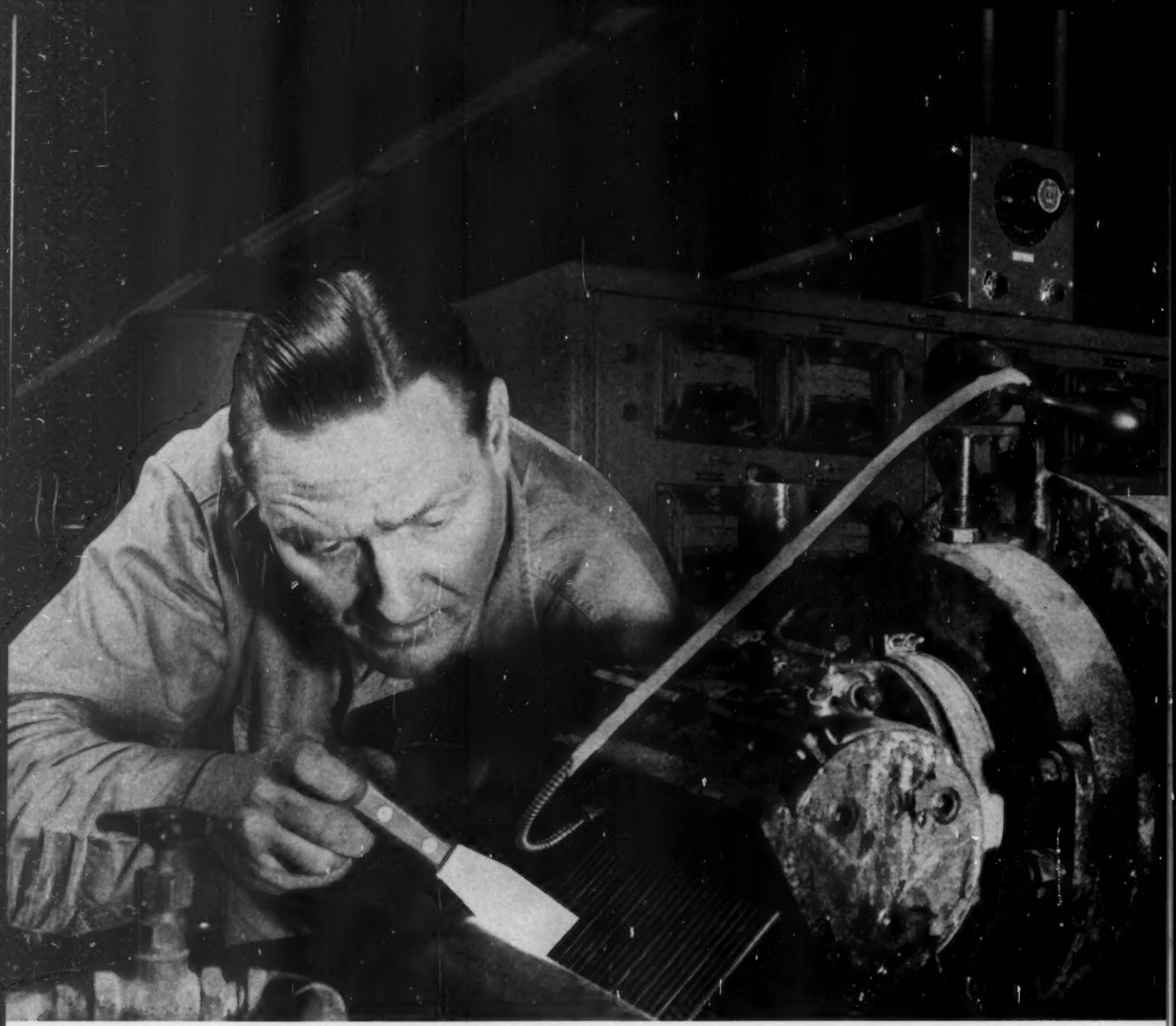


THE TURN OF ONE DIAL MATCHES PROCESS SPEEDS TO CHANGING PRODUCT DEMANDS

The value of the Reliance Super "T" V★S Drive on this extruder is in its ability to produce and hold accurately the wide range of specific speeds necessary to handle a variety of plastic materials.

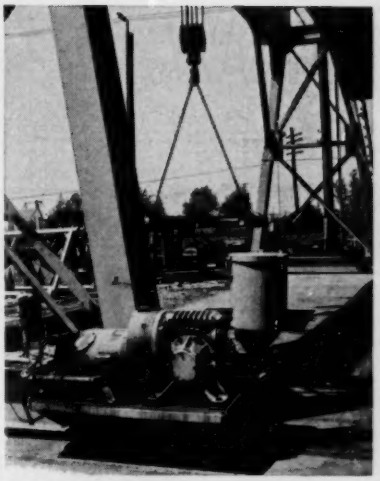
Polyethylene, polystyrene, nylon and PVC are among the plastics that are color-compounded, heated and extruded for pelletizing. Each one calls for a different machine speed and setting. Motor operating speeds can be varied from 145 to 2000 rpm . . . and within the range, the V★S Drive maintains the exact speeds needed to extrude and pelletize each type . . . and this even includes zero speeds for set-up.

These perfectly controlled speeds and the 24-hours-a-day, 7 days-a-week use demanded by this plant's production schedule are the basic reasons why Plastic Materials and Polymers, Inc. has standardized on Reliance V★S Drives in all three of its plants.

BUILDERS OF THE TOOLS OF AUTOMATION

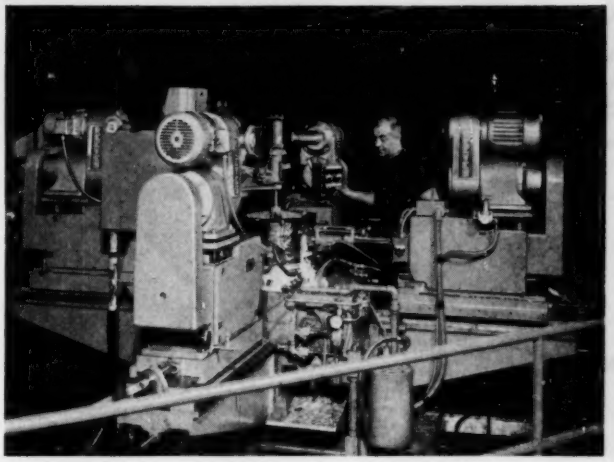
A-1683

ONE SELF-CONTAINED, COMPACT POWER PACKAGE. This MASTER GEARMOTOR has been operating outdoors for 5 years regardless of weather. It has no exposed high speed couplings, no V-belts, chains or sprockets. Engineering and assembly costs are reduced. You can simplify installations and save space with vertical, horizontal and flange mountings; output shaft over, under, left or right. Ratings 1/8 to 125 hp. in right angle, parallel or in combination. Right angle ratios are available in 96:1; parallel 120:1. Bulletin E-2409.



CONTOUR EPOXY-COATED TO ELIMINATE ENCAPSULATION CRACKING. New RELIANCE ENCAPSULATED MOTOR . . . gives you positive protection from dust, dirt, acid and water. Unlike other heavy molded coatings, stator windings are vacuum-impregnated with epoxy resin at a uniform thickness, follow the contour of the windings. You get maximum flexibility, tensile and bond strength, plus quicker cooling . . . all vital to superior motor performance. Bulletin B-2108.

INFINITELY VARIABLE OUTPUT SPEEDS AT LOW COST. REEVES MOTODRIVES, shown here powering this 4-position drilling and boring machine, are used extensively for hundreds of production needs. Horsepower ratings from ¼ to 40, speeds from 1.71 to 4660 rpm. Speed variation ranges from 2:1 to 10:1. Available in hundreds of space-saving assemblies . . . with manual, remote or automatic process control (Airtrol). Bulletin M-592.



TOTAL SERVICE is an integral part of every Reliance product, from engineering and start-up assistance to maintenance and renewal parts. The photo shown here is typical of a Reliance Service Engineer's on-the-job availability—for maintenance and consultation on knotty problems. Every Reliance Sales Engineering Office and Distribution Center—nationwide—gives you the attention and experience necessary to assure the top performance you expect from the Reliance equipment you buy.

RELIANCE ELECTRIC AND ENGINEERING CO.

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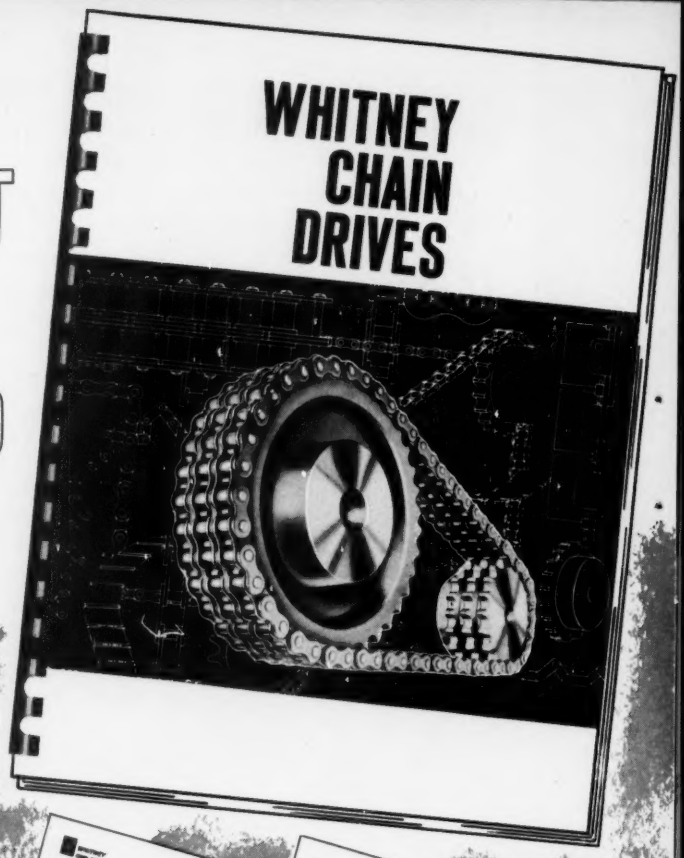
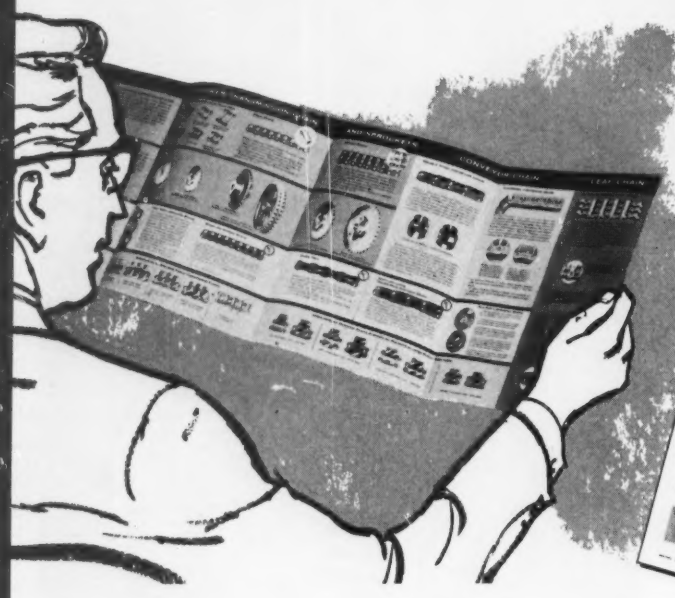
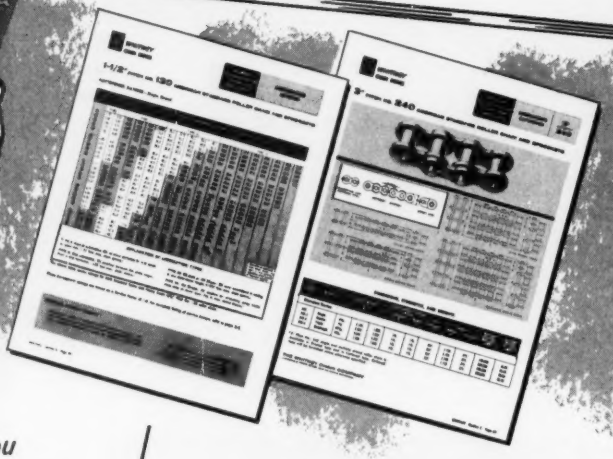
Circle 474 on Page 19

NOW... YOU CAN SELECT CHAIN DRIVES WITH INCREASED CAPACITIES!







A completely new manual designed to help you choose the right chain drive for any application...

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- UNIQUE NEW SELECTION PROCEDURES... SIMPLE, QUICK, ACCURATE.
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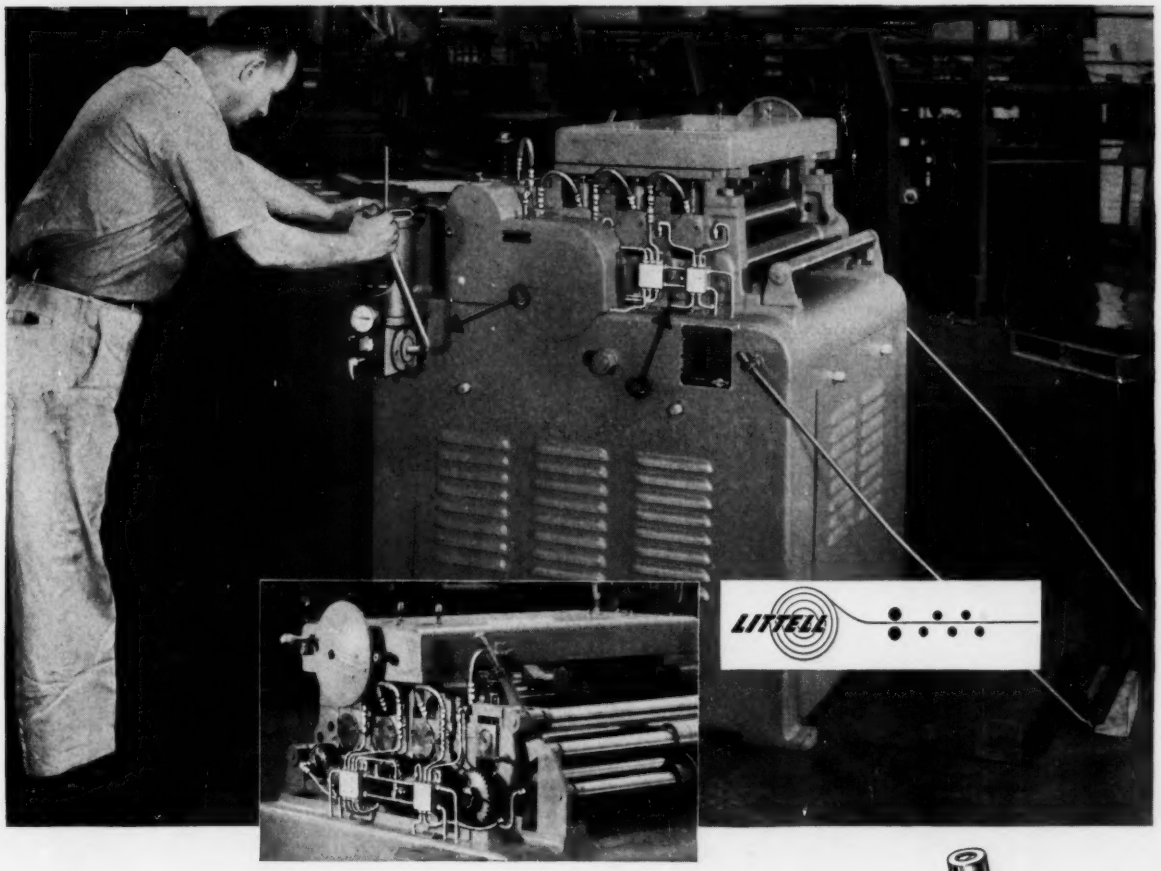

Farval Centralized Lubrication on Littell Straightening Machine Eliminates Down-time, Saves Bearings

This versatile No. 424 Littell Machine straightens coiled steel stock .050" thick by 24" wide, and automatically supplies a free loop of pre-straightened stock at proper speeds required for smooth, efficient punch-press operation—even through the most complicated progressive dies.

Keeping press output at top level allows no down-time for the Littell No. 424 straightener. Its built-in Farval Manual Dualine System protects the machine's 24 most important bearings—keeps them adequately lubricated while the machine remains continuously on the job.

On industrial equipment all over the world, Farval delivers measured amounts of clean lubricant at regular intervals to all vital bearings. From a central station, lubricant is pumped under pressure to a measuring valve at each bearing, providing the exact amount of lubricant desired.

If you want your production equipment to stay in top-operating condition—to reduce costs, boost profits—then write for free Bulletin 26-T. It tells the complete "Farval Story".

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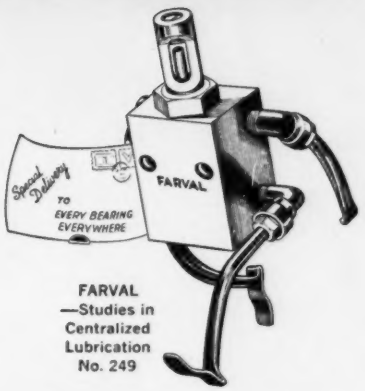


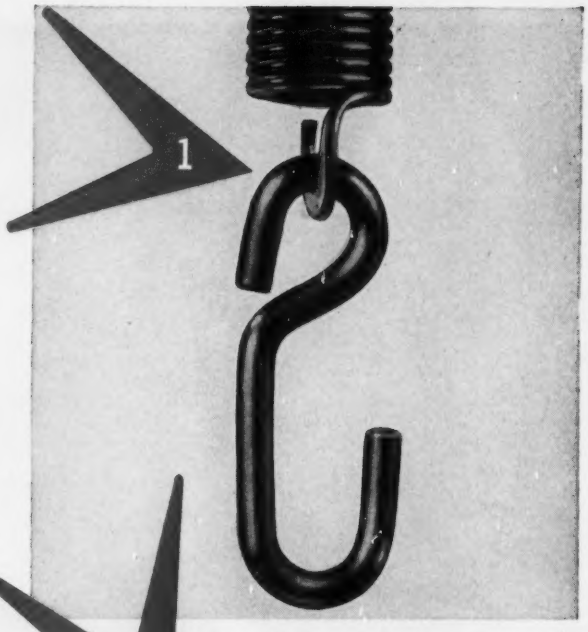
FARVAL
—Studies in Centralized Lubrication
No. 249

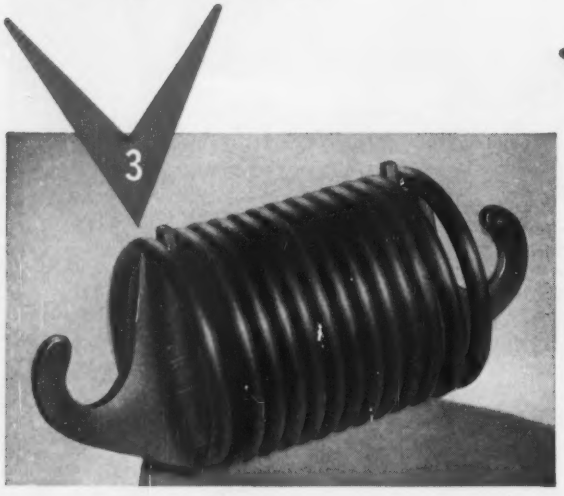
KEYS TO ADEQUATE LUBRICATION

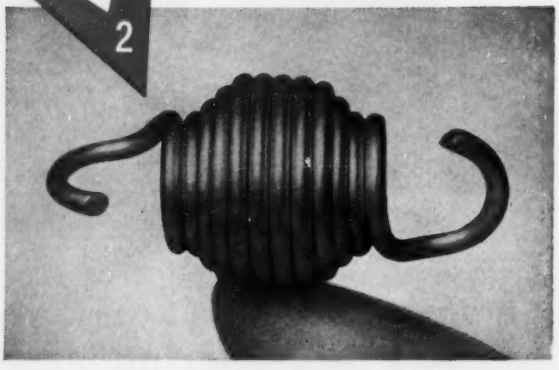
—wherever you see the sign of Farval —the familiar valve manifolds, dual lubricant lines and central pumping station—you know a machine is being properly lubricated. Farval manually operated and automatic systems protect millions of industrial bearings.

Circle 476 on Page 19

Why it pays to look at the end in the beginning







1. In this pick-arm spring for a textile machine, natural frequency vibration plus rigid end restraint caused early failure. By redesigning spring and adding swivel hook to end assembly, failure was avoided and cost reduced as well.

2. Fatigue failure caused by bending stresses occurs where end hooks join working coils. In this method of reducing the combined stress, two coils at each end are wound with a reduced diameter.

3. Another method for reducing stress concentration where end hooks join coils is to thread a flat stamping into end coils.

Here are a few examples of why it pays to call on the springmaker early in your design problems. End-hook failure of extension springs is a common occurrence that experience can help avoid. Check your specifications for performance and production economy by consulting an A.S.C. spring engineer. Write for bulletin "How to Solve Your Spring Design Problems."

9903

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So gentle it won't chip china, yet powerful enough to bend steel tubing as if it were a soda straw. In a nutshell, this demonstrates the almost unbelievable degree of control built into Logan air-draulic devices.

The controlled accuracy gives this equipment a versatility and flexibility that makes it adaptable to all kinds of jobs, ranging from precision laboratory assignments to actual production line work.

If you would like additional information about air-draulic devices or other Logan products, merely fill in the coupon below.

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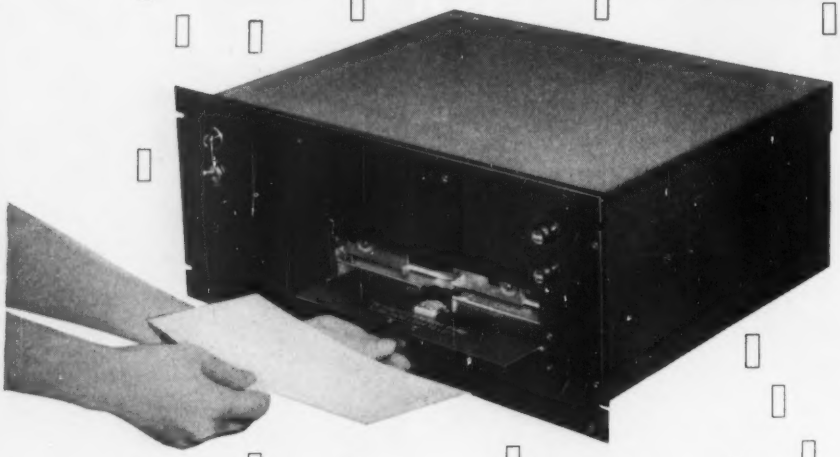
DIRECT CONTROL PROGRAMMING



INDUSTRIAL TIMER

PUNCHED CARD AND PUNCHED TAPE

PROGRAMMING EQUIPMENT

Automatic equipment designed to provide direct control, without coding or decoding, for as many as 85 individual load circuits, through 30 or more different steps of an industrial process.

The Programmer is governed by a simple, punched vinyl card. The card or tape is advanced from position to position by a simple external switch closure signalled by feedback, time, limit switch, thermostat, and many others.

Programming equipment operated by punched tape is also available. Modular design permits addition of accessory banks of memory-type load relays. Industrial Timer Programmers are now in use for the automatic control of steel and aluminum blooming mills, structural steel fabrication, batching solid rocket fuels, and many other industrial processes.

Complete information in Bulletin 100, sent on request. Write or phone.

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INDUSTRIAL TIMER CORPORATION

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Circle 479 on Page 19

Circle 480 on Page 19→

Sharp-shouldered Bolt for a Precision Fit Made from KEYSTONE WIRE

Quality Fasteners, Inc., Kalamazoo, Michigan, serves many markets with its heading specialties. One such specialty is a D-shoulder bolt for a supermarket food cart caster, designed so it will key into the caster structure. This bolt is headed from annealed-in-process Keystone Heading Wire with Lime Brite finish. Quality Fasteners, Inc. heads this specialty without a relief attachment.

Chester Werme, veteran cold-header, President of Quality Fasteners, knows his wire. He buys Keystone Wire for all his forming operations, because, as he says, "We know what this wire will do and we design our products around it."

At Quality Fasteners, flowability of Keystone Wire is the secret which assures uniform quality, sharp shoulders and edges, correct tolerances with accurate dimensions. The result: Considerable savings and a better product over other machining techniques.

So, when you contemplate forming a product from wire, remember the superior flowability characteristics of Keystone Wire. Our Wire Specialists are always ready to consult with you about your wire forming problems. We invite you to call or write.

Keystone Steel & Wire Company, Peoria, Illinois

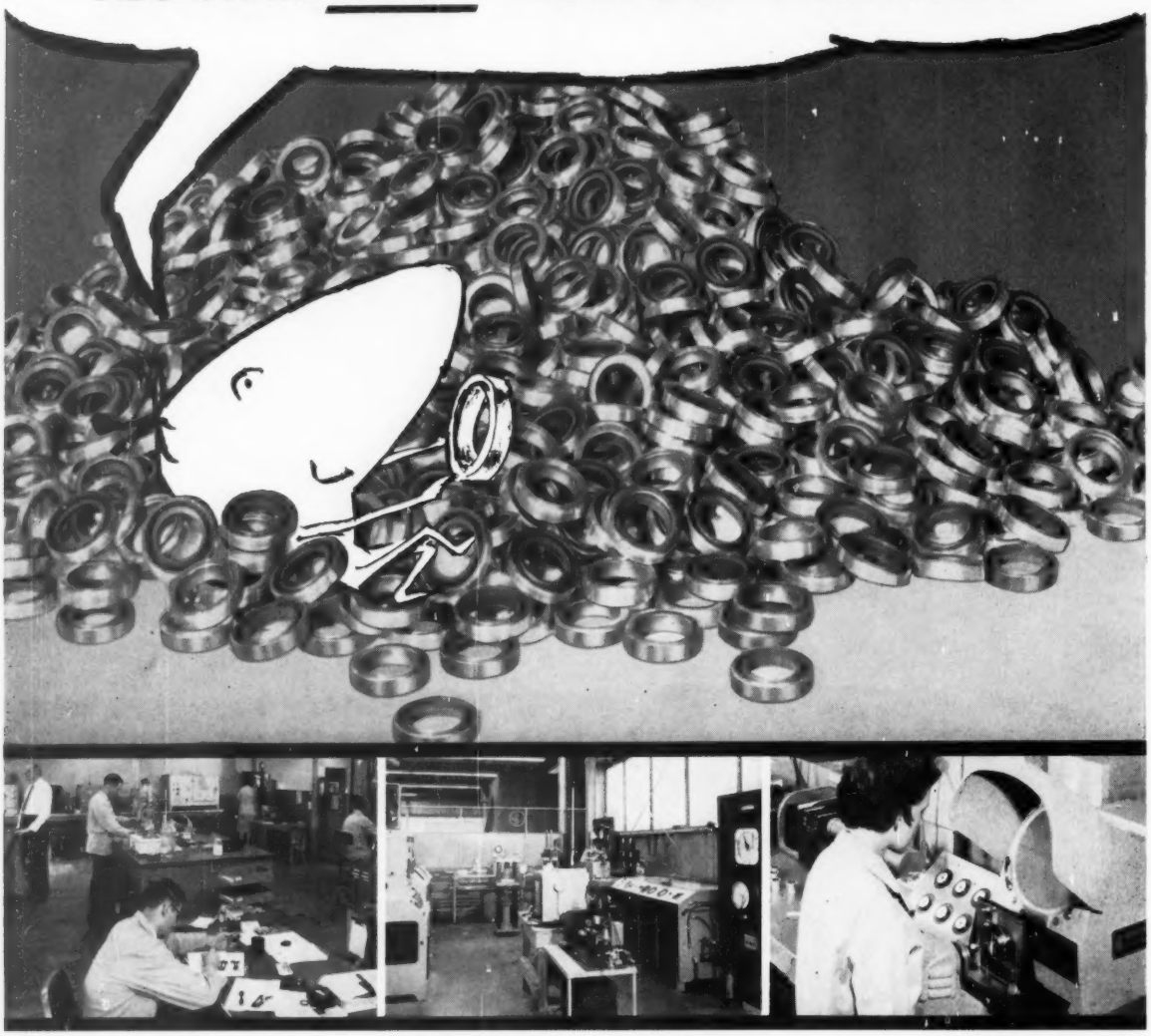
KEYSTONE COLD HEADING WIRE STUDY

KEYSTONE

WIRE FOR INDUSTRY

MANUFACTURED AT PEORIA, ILLINOIS, U. S. A.

YES SIR... THAT'S "CUSTOM" CONTROL!



Control laboratory determines compound best suited to your need.

Engineering Test Laboratory check final design . . establish tolerance limits for production.

"QC," Quality Control technicians are located throughout the plants to examine your parts as they're being made.

It takes more than machines to turn out a consistent, *uniform* batch of oil seals . . . That's why IPC started the highly critical "custom control system."

After engineering and lab analysis a specific recommendation of manufacture is made for *your* oil seal. Critical tolerance levels are established to guide the many Quality Control people who will follow your parts as they move through our plants. At any time, our QC department can halt production if they find variances in manufacture.

Result? . . . *Uniformity* . . the assurance that IPC is controlling quality for you.

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DESIGN

February 16, 1961

The Next Step?

DISSOLUTION of the Engineers and Scientists of America marks the end of a noteworthy chapter in engineer-employer relations. Whether the ideals and objectives of the group will continue in other organizations remains to be seen. But it is significant that Joseph Amann, ESA president, now predicts that engineers will have to choose between professionalism and unionism.

The notion that the two could be compatible seemed to be a basic tenet of the now-defunct federation, though engineers on the outside, by and large, have disagreed. Why?

A professional man identifies himself with the interests of his client or employer. He teams up with his client to fight a common problem.

A union man regards his employer as an antagonist — not necessarily unfriendly, but nevertheless on the opposite side. He teams up with his fellow workers against his employer to fight for something that he feels the employer would withhold if he could.

That is why ESA affiliates, and other collective bargaining units of engineers, came into being and were reasonably effective. Engineers had reason to feel that employers, especially the large ones, were withholding full recognition of the contributions that engineers were making and could make toward the success of the corporate enterprise.

Yet the very act of banding together to demand recognition by force of numbers and threat of action prejudiced their claim to recognition as professionals.

What's the next step? If Mr. Amann is right, and if enough employers fail to see the light, engineers banding together for collective bargaining may throw aside the pretense of professionalism and align themselves with organized labor.

More hopefully, employers increasingly may be wise enough to treat their engineers as professionals, and thus remove the pressure for collective bargaining, labor-union fashion.

It looks as if the extent of future unionization of engineers will depend pretty much on the employers, doesn't it?

Colin Carmichael

EDITOR

Bids on contracts for technical projects always involve a certain element of risk. Superior engineering qualifications do not guarantee acceptance—a technically sound bid may easily lose out because of poor presentation. On the other hand, a polished, well-prepared proposal is an asset. But it won't make up for technical deficiencies.

Here's an engineer's guide to preparing proposals, with tips on how to avoid the common pitfalls of bid presentation.

Technical Proposals

To Bid or Not To Bid

The strategy involved in decisions to bid or not to bid on a technical project has a direct effect on the time and money spent in evaluating a bid invitation or preparing a technical proposal. Here are the conditions and strategies that may be involved.

Company Plans To Bid

- Real competition exists (there is no favored bidder) and the company either wants the contract or simply wishes to establish or maintain a good relationship with the contractor.
- Real competition is not believed to exist (one bidder is apparently favored because of either qualifications or other factors) but bids are requested to fulfill the requirements for competitive bidding.

Company Declines To Bid

- Situation is not really competitive in that the contractor has close contacts with a bidder who has a favored position because of high qualifications for such work or other factors.
- Company is not qualified to do the job.
- Previous dealings with the contractor or the contractor's agent have been unsatisfactory to the point that it probably would be impossible to form a satisfactory working relationship.

for Contract Projects

D. W. KARGER and R. G. MURDICK
Dept. of Management Engineering
School of Engineering
Rensselaer Polytechnic Institute
Troy, N. Y.

BIDS for undertaking engineering projects on a contract basis always involve the preparation of a technical proposal. The more advanced or novel the project is, the more important proposal content and organization become.

Strategy and logic behind a technical proposal do not change essentially because of the organization receiving the bid. It may be a government agency, a prime contractor, a subcontractor of government work, or a private firm with no government affiliation. Technical proposals are usually solicited; however, unsolicited proposals are common and sometimes result in major contracts.

In large companies, an internal proposal to another division or top management can be just as important as a proposal to an outside contractor or firm. Regardless of who is on the receiving end, winning proposals require a lot of hard work in their preparation and must be backed up by both business and technical facts.

Proposal Team

Technical proposals are usually prepared by a team made up of representatives from: 1. Marketing. 2. Engineering and/or research. 3. Manufacturing. 4. Finance and/or accounting. While the nominal leader of the team is the marketing representative, this job very often becomes a co-operative undertaking shared by both the marketing and the engineering representatives.

This team concept is illustrated by the organization chart in Fig. 1. Such proposal groups or bid teams are usually temporary arrangements and the individuals only spend part time on proposal work.

Responsibilities of each team member should be clearly defined. The engineering representative is responsible for the technical content of the proposal; however, this responsibility is shared with the research representative when research activity is involved. The manufacturing representative is generally responsible for all facts relating to production of hardware, including schedules, related cost details, tool lists, facility lists, extent of production know-how and skills, etc.

The finance representative usually has a twofold responsibility: 1. Compilation of all cost data. 2. Fulfillment of auditing requirements. His auditing activity is basically concerned with the compilation of costs. Since much of this information is not directly available from his own activity and must be drawn from engineering, purchasing, and manufacturing, he must be responsible for the accuracy of the data. To meet this requirement, he must serve as an auditor in the truest sense. Not only must he audit the basic data but also the over-all financial aspects involved in the pricing of the bid. Often, the financial officer also takes part in establishing bid prices.

The sales or marketing representative is responsible for the tenor and tone of the proposal wording; the production of the actual proposal, including art work; and the final pricing of the bid, subject to general top-management approval. As

nominal leader of the team, he is also responsible for seeing to it that the team members complete their jobs on schedule.

In larger companies, most of the basic work in producing the proposal and art work is performed by the technical writing and graphics groups. The marketing representative merely reviews their output, changes it where necessary, and, in general, makes sure that deadlines for the production of the bid are met.

The purchasing function is not always represented on the bid team. However, a purchasing representative may be included when production of actual hardware is involved and purchased material represents a high percentage of the manufactured cost of the resultant product.

Preliminary Steps

A bid team's first step in preparing a proposal is to study and evaluate the request to bid. The specifications involved may be either general or detailed. If they are extremely general, it is up to the bidder to fill in any necessary detail and to see to it that he is properly covered against the eventuality of detailed specifications being produced later by the contractor.

If the specifications are detailed, each item should be carefully examined. Acceptance or rejection of a proposal may hinge on the attention given to some obscure requirement in the "fine print." Loss of a bid can be a costly price to pay for mistakes.

The problem in preparing proposals is not one of getting too much information but, rather, how to avoid not getting enough. Members of the bid team should take advantage of every possible opportunity to discuss the bid invitation with representatives of the contractor, particularly the ones concerned with technical requirements. In addition, the possibility of having a specialist consultant to assist in the preparation of the bid should not be overlooked.

Once the detailed information has been obtained, company management must take stock of the various factors that govern its bidding position:

1. Available technical competence in terms of estimated requirements.
2. Workload and job-priority assignments.
3. Required facilities and working capital.
4. Strength of known competitors.
5. Possible profit in view of competition, nature of job, and forecast of future requirements.

From such an evaluation, management must decide either to continue with the development of the proposal or to drop the effort. If the decision is in favor of going ahead, engineering draws the first assignment:

1. Review previous successful and/or unsuccessful efforts to solve similar problems.
2. Attempt to develop new, economical, and technically sound approaches to the problem.
3. Analyze thoroughly all alternative approaches and prepare reasons why these are not as favorable as the company's approach.

Step 3 of this procedure is dependent upon the sucessful accomplishment of Steps 1 and 2. In practice, its importance is very often underestimated and bids are frequently eliminated because a concept involved had one or more of the following characteristics:

1. Development would involve high risk with insufficient compensatory advantage.
2. Resulting product would be larger, heavier, less accurate, slower in operation, etc., than one using an available alternative.
3. Design would not provide for future increase in capacity or power.

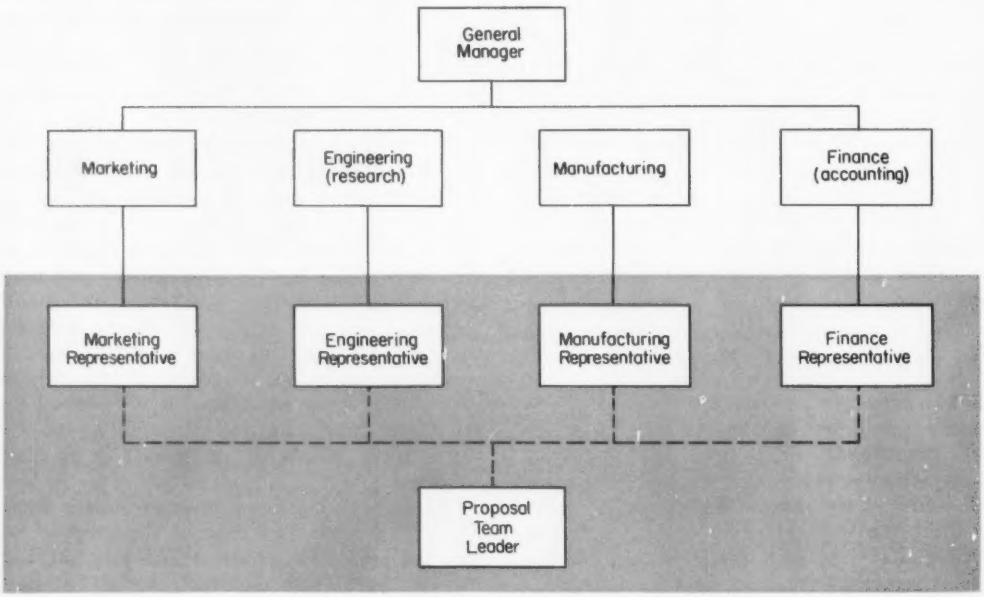


Fig. 1—Organization chart for typical proposal team.

Proposal Content

1. **Introduction or Abstract (Initial Summary).**
   Present brief, summary-type opening statement which contains clear concise statement of the technical requirement, particularly for unsolicited proposals; brief analysis of the problem; summary of proposed method of solution; explanation of relation of solution to broader concepts, such as the over-all system; description of hardware to be supplied; conservative estimate of performance, including a realistic time table; estimate of costs; statement of the company's ability and willingness to devote its resources to the proposed work.

2. **Proposed Solution.**
   Develop solution by using as many chapters as there are significant parts to the basic solution. In addition, give alternative solutions and their advantages and disadvantages. If the proposal does not involve solution of a technical problem, provide a "Listing of Equipment" which contains complete list of equipment to be supplied as well as comments on adherence to specifications.

3. **Supporting Argument.**
   Present convincing reasons why the proposed solution is the best one. Include comparisons to alternative solutions. If possible, show why alternative solutions are not as good.

4. **Qualifications of Company.**
   Show as completely as possible why the company is best qualified to do the job. Discuss company organization, key personnel, laboratory and test facilities, major customers, major products, etc.

5. **Method of Approach.**
   Provide an outline showing the over-all plan of attack, including personnel assignments, facilities, procedures, scheduling techniques, design schedules, manufacturing schedules. Keep in mind that the objective here is to indicate as clearly as possible the company's practical approach to developing the solution and/or supplying the hardware.

6. **Cost Data.**
   Supply complete cost data in accordance with the bid request. Make sure that all cost data is converted into the form requested by the contractor.

7. **Conclusion.**
   Summarize what has been said, emphasizing the strong points of the proposal.

8. **Appendixes.**
   Use this section to present such items as complicated mathematical derivations, resumes of key personnel, facility lists, and general organization charts of the company. This section usually includes annual report of company.

4. Project would be committed to a single design approach with no apparent support in the form of alternate design concepts and/or hardware.

These concepts are the basic considerations in proposal preparation. They underline the importance of analyzing alternative approaches.

Proposal Content

A good proposal should include the information shown in *Proposal Content*. Outlines of two actual proposals are given in *Typical Technical Proposals*.

One of the most important sections in a technical proposal is the initial summary. It is read by more persons in positions of authority than any other part of the proposal. Its objective must be to convince the contractor that the bidder is fully capable of meeting his needs. The summary should be brief —no more than two or three pages in length. In unsolicited proposals, the summary should include a statement of the technical requirement which the

Typical Technical Proposals

Bid to Furnish Advanced Equipment

1. Introduction
2. Schedule
3. Organization
   a. Chart
   b. Personnel data sheets
4. Equipment to be furnished
5. Preliminary recommendation of spare parts and special tools
6. Temperature-measurement sets description
7. Pressure-measurement sets description
8. Flow-measurement sets description
9. Liquid-level-measurement sets description
10. Cost data and proposed price

Bid to Furnish R&D and System Equipment

1. Quotation
2. Comments on "Request to Bid" item by item
3. System description
4. Components
5. Components
6. Components
7. Company facilities
   a. Company and subsidiaries
   b. Management
   c. Key men in engineering
   d. Major customers
8. Bill of materials
9. Drawings, specs and component bulletins
10. Cost data and proposed price

proposal fills. For solicited proposals this statement can be omitted.

When a bidder takes exception to any part of the specifications he very often causes his proposal to be rejected as being unresponsive. If such action is necessary, the reasons should be clearly stated. If possible, this statement should show why the exception is unimportant as related to the over-all proposal and, also, why the specification in question is impractical or unnecessary.

From an engineering view, technical content of a proposal is of primary concern. However, organization, schedules, and proven ability of the bidder to produce are of almost equal importance. Schedules—both engineering and production—are particularly significant. Usually, the contractor must have equipment operational within a certain time if it is to be of any value to him. The proposal should give detailed schedules, with major milestones indicated in chart form. If the contractor is the government, major project phases might be programed so that they coincide with government fiscal periods to prevent subsequent delays in handling funding problems.

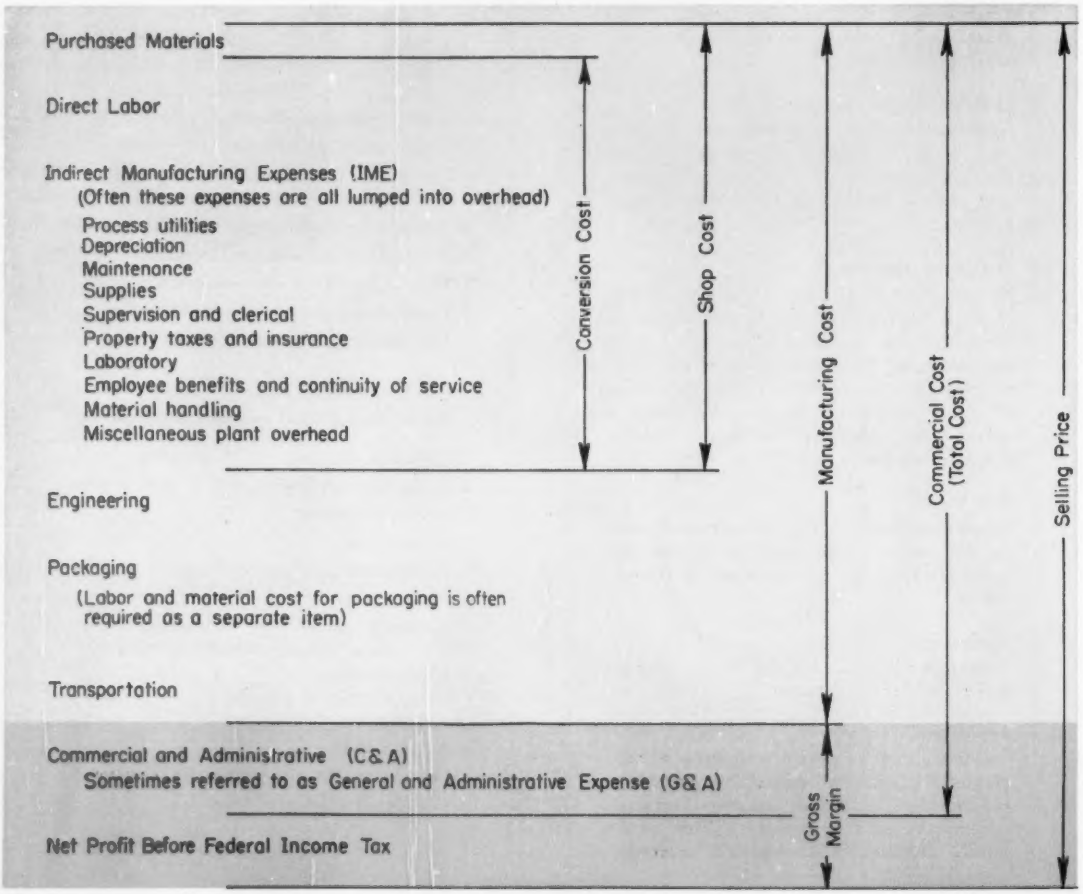
Former practices of padding proposals with "filler" material taken from old files, using expensive color and artwork to cover up lack of technical content, and making exaggerated sales pitches are worthless and should be avoided. Such practices work against the bidder more often than they aid him. Contractors today are technically competent and sophisticated and can easily "see through" such subterfuges. Other pitfalls that should be avoided in proposal preparation include:

1. Oversimplification of the technical problem.
2. Lack of responsiveness to specifications, or misinterpretation of requirements.
3. Reliance upon too-advanced concepts which are not technically feasible within the specified time.
4. Overoptimism about performance requirements.
5. Lack of awareness of the necessity to integrate equipment with system requirements.
6. Vague generalities.
7. Insufficient detail on costs and pricing.

Costing and Pricing

To be a winner, particularly where price is the deciding factor, the proposal must clearly show that cost estimates are realistic and reasonably accurate. If hardware is to be produced and bills of material as well as specifications are available, the bidder

Cost and Price Checklist



Proposal Evaluation

. . . a study of a successful bid

In 1958, the National Aeronautics and Space Administration invited proposals for R&D work to develop a rocket engine. The NASA later issued a detailed statement of reasons for selection of the successful proposal. Here is a summary of that report:

Proposal A

- Proposal was nonresponsive to two parts of the specification.
- Proposal requested development of a new test facility instead of contemplating use of present facilities.

REJECTED

Proposal B

- Design was based upon a concept unproven for an engine of the specified size.
- Proposed method of control presented unusual and difficult design and development problems.
- Proposal appeared in general to be a high-risk development with insufficient compensatory advantages.
- Test schedule and total test man-hours were unrealistic and therefore the estimate of cost appeared to be unreliable.

REJECTED

Proposal C

- Although the proposal was technically conventional, it was inferior in design in terms of the present state of the art.
- Engine was the heaviest and largest of any engine proposed.
- Scheduled number of engine tests and the test time appeared unrealistic.
- Estimate of costs was the highest received.
- Physical facilities and technical capability of the company at the time were of doubtful adequacy without some build-up of facilities and personnel.

REJECTED

Proposal D

- Proposal was responsive to the requirements.
- Proposal was based upon a design generally within the present state of the art.
- Proposal manifested a mature appreciation of the major technical problems and, in addition, was backed up by alternative design concepts and hardware.
- Company's test program permitted early thrust-chamber tests, and development of the thrust chamber represents one of the major items which will pace the entire engine development.
- Company's experience in the large liquid rocket engine field, its existing facilities, and its technical capabilities were comparatively superior.
- Cost estimates appeared realistic and reliable.

ACCEPTED

should secure quotations, preferably two or three, on at least all of the major items of purchased material. A statement as to how the labor cost was computed should also be included in the proposal.

The ultimate bid price must take into account not only costs but also potential future business of a similar or the same nature. Sometimes a bidder may take a first contract at a loss to place himself in a preferred position for subsequent business.

Cost usually is not the prime factor in determining the order of acceptability of bids. However, it ranks high in importance since contractors wish to stretch their funds as far as possible.

If a Government contract is at stake, and the bidder has not had experience in bidding, pricing, and actually operating under such contracts, he should seek expert counsel before submitting his proposal. Despite all of the detailed Government instructions and regulations on costing and bidding, firms continue to submit proposals which omit some important element of cost. A number of companies have actually failed because of improper bidding on Government contracts.

As an aid in proposal preparation, the accompanying *Cost and Price Checklist* might well be used as a basis for a final over-all review of the costing and pricing operation.

Proposal Appearance

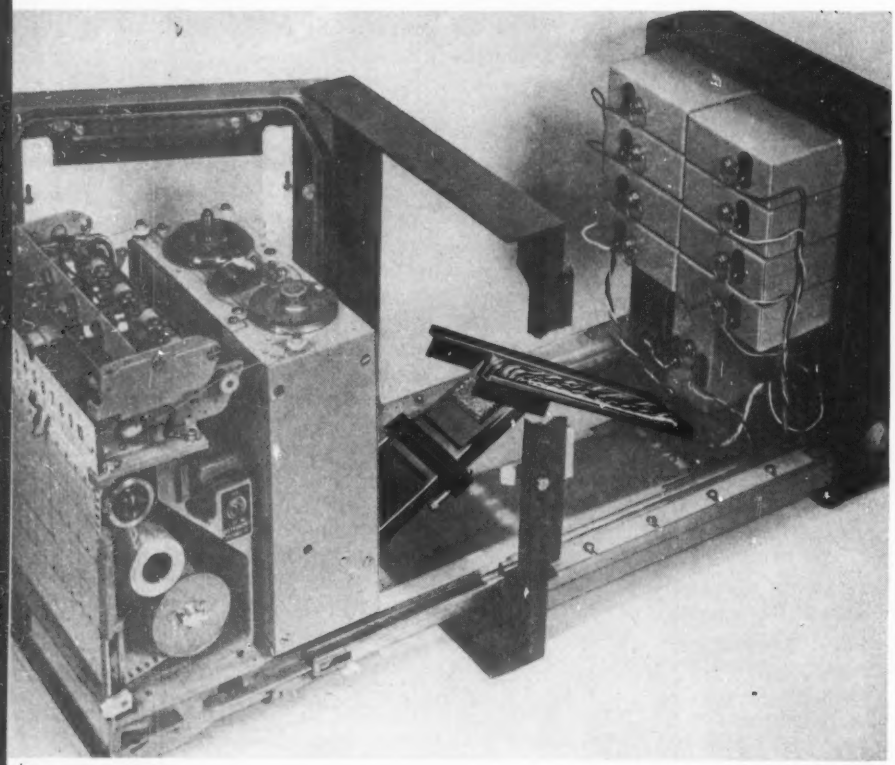
A beautifully adorned proposal elaborately illustrated with isometric drawings and colored overlays will not overcome technical deficiencies. Conversely, an untidy proposal with insufficient charts and illustrations, poor reproduction, and generally unprofessional appearance can result in the bidder's losing out despite a technically superior approach. Sometimes, contractors take advantage of information obtained in initial bids to guide a second round of bidding. In such situations, a neat, professional presentation is essential.

For these reasons, the proposal should be prepared on standard size paper and neatly typed (double spaced unless it makes the proposal too voluminous) with adequate margins for notes. Black-and-white line drawings and photographs should be used for illustrations, unless color is necessary for clarity. Conservative, inexpensive covers are appropriate.

Cover Letter

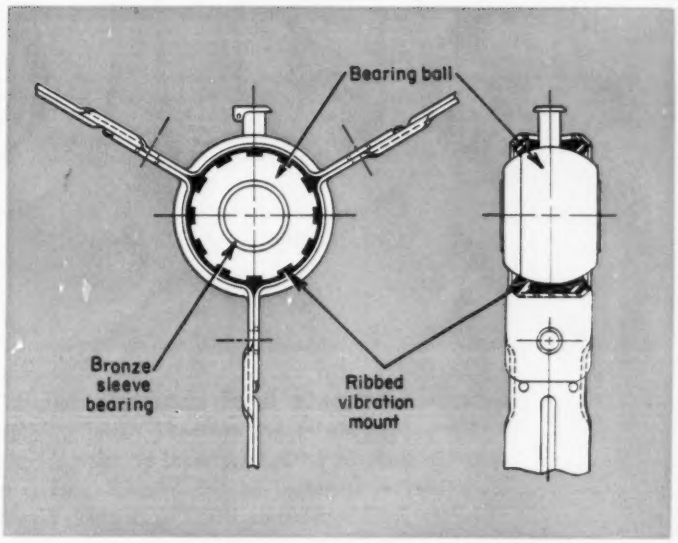
The letter transmitting the proposal or bid will be the first item read and can be a potent selling aid. If the cover letter includes an important "sales pitch," a copy of it should be attached to each copy of the proposal. Otherwise, the contents of the letter may never be seen by the people who receive the extra copies of the proposal for evaluation. This letter is also the ideal place for personalizing a proposal or bid through mention of specific individuals, situations or other appropriate references which do not fit in the bid itself.

scanning the field for *ideas*

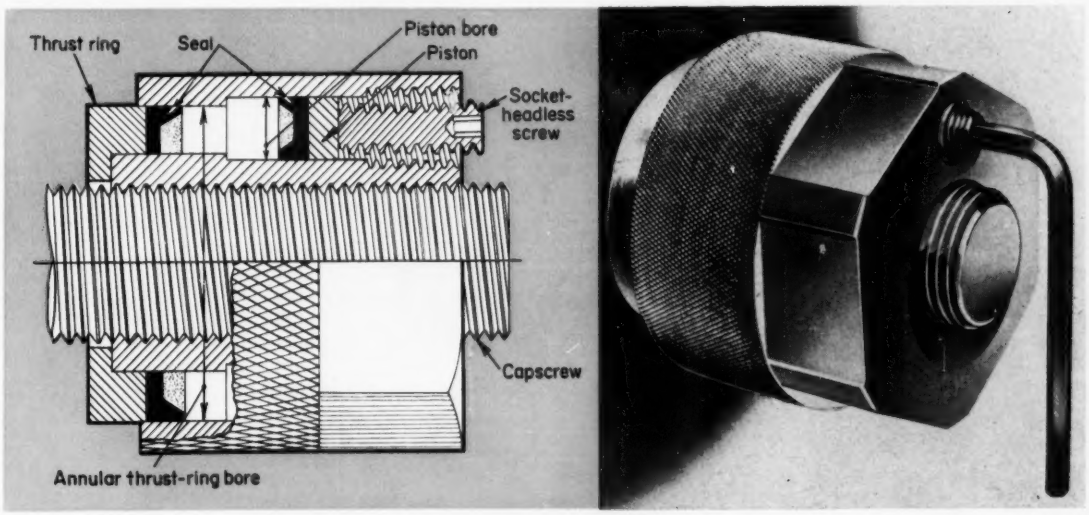


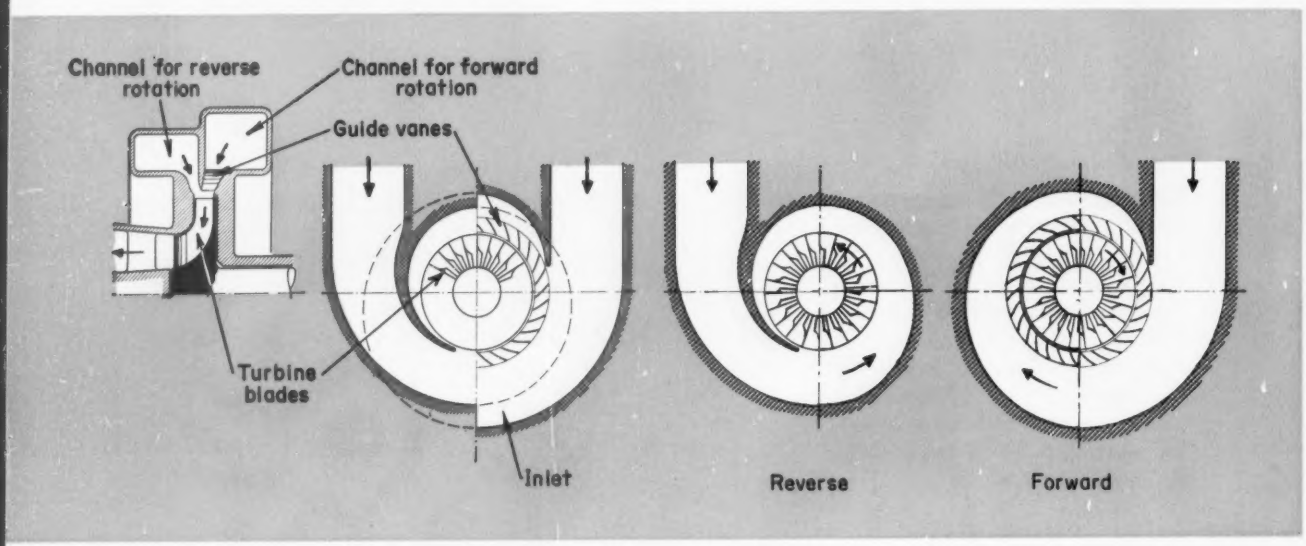
Wiring drawbridge supports flexible leads to permit easy removal of instrument module. When the module is reinserted, the drawbridge folds into a vertical position. Principle employed in potentiometer by Minneapolis-Honeywell Regulator Co., Philadelphia.

Ribs in vibration mount permit passage of cooling air and decrease vibration transmission of a self-aligning bearing. The bearing ball, which contains a porous bronze sleeve bearing and a felt oil reservoir, is restrained axially by the ribbed mount. Principle employed in bearing bracket assembly developed by Triangle Mfg. Co., Oshkosh, Wis.



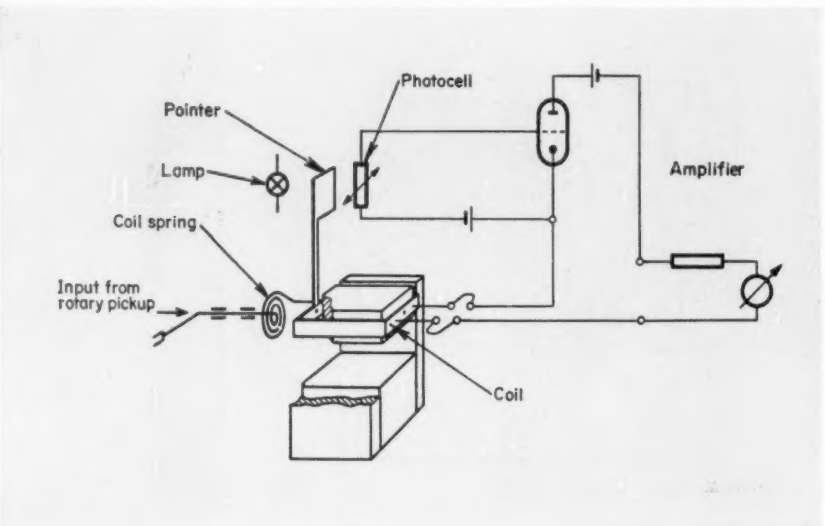
Hydraulic nut provides torqueless tension. A small hydraulic piston, actuated by a socket-headless screw, applies hydraulic pressure to an annular thrust ring. Thus, a small, finger-powered wrench produces high clamping force in the joint. Hydraulic tensioning principle employed in a nut by Euco Tools Ltd., Kingston-upon-Thames, Surrey, England.

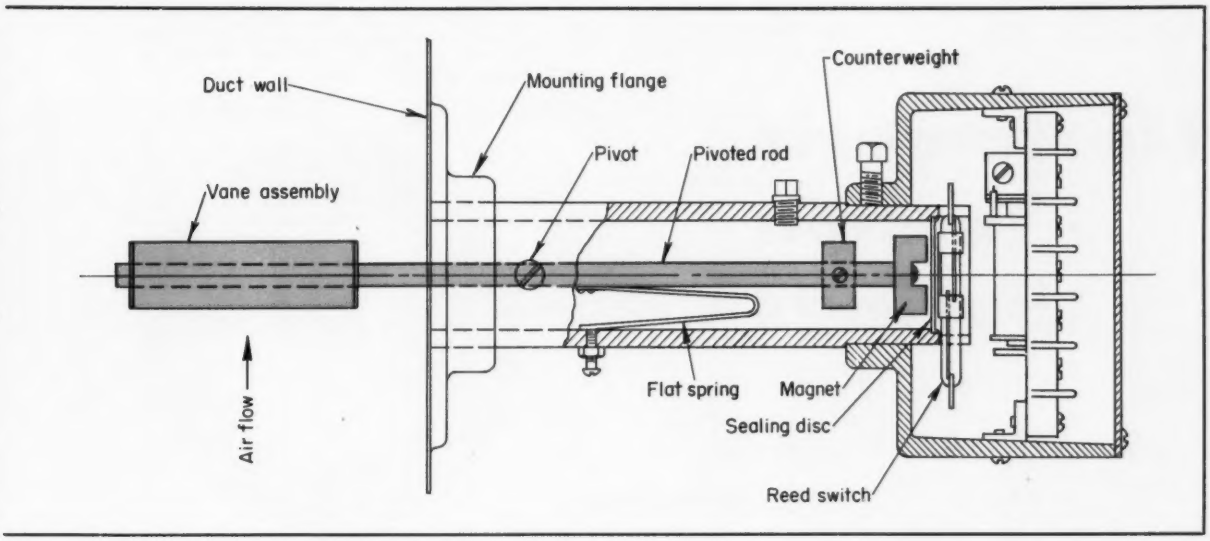




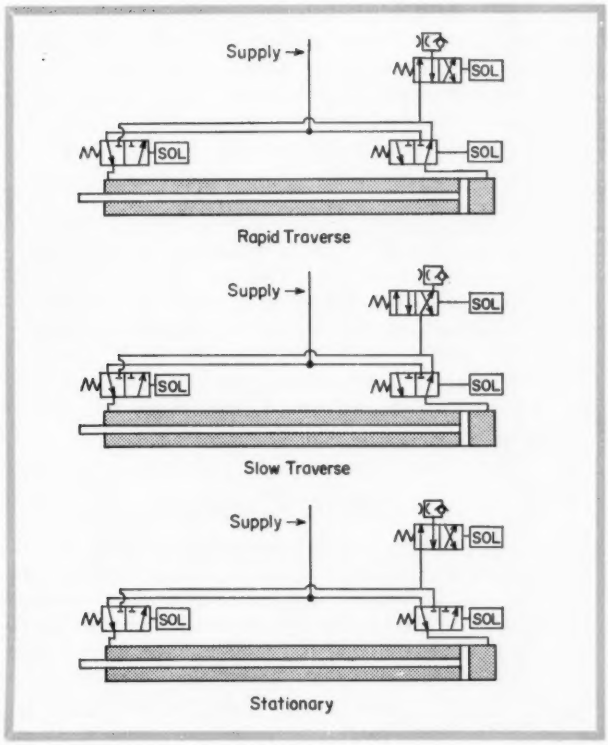
Alternate inlet channels control direction of turbine rotation. The turbine blades are arranged radially. Stationary guide vanes direct the incoming fluid to produce forward rotation. For reverse rotation, the spiral fluid circulation imparted by the inlet channel is sufficient. Principle employed in centripetal turbine designed by Escher Wyss, Zurich, Switzerland.

Pointer-shaded photocell adjusts feedback to supply a controlled counter-torque to a rotary motion pickup. Current controlled by a photocell is applied to the moving coil. The resulting torque is in opposition to the primary torque output of the motion pickup. Principle can be used for null balancing or for changing input signal to desired output form. Technique employed in transmitter manufactured by J. C. Eckardt AG, Stuttgart-Bad Cannstatt, Germany.





Vane-controlled magnet actuates a reed switch in response to presence or absence of air velocity. Velocity pressure of the air stream positions the vane in opposition to the return spring. When air velocity drops below a predetermined value, the vane rod pivots and repositions the switch-actuating magnet. Principle employed in velocity switch developed by Drying Systems Co., Chicago.

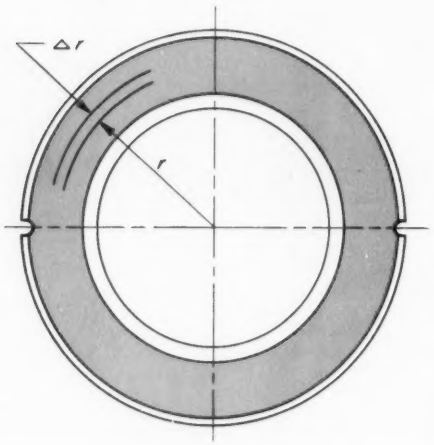


Two throttling rates permit selection of slow or fast piston speed by a simple series-valve arrangement. For rapid traverse, one end of the cylinder is exhausted directly to the atmosphere. For slow, controlled travel, the exhaust air is metered through a second valve. The piston is held at any desired position by applying pressure to both sides of the piston. (Weight and friction overcome effect of differential area.) Principle employed in a reel winder by National Electric Welding Machines Co., Bay City, Mich.

Elastomeric Torsion Springs

- *Basic Concepts*
- *Design Considerations*

Fig. 1—A typical elastomeric torsion spring consisting of two concentric metal tubes and a cylindrical body of elastomer between them. Shrinking stresses caused by cooling of the bonded elastomer are relieved by using split outer shell.



ALVIN S. KROTZ*
Consultant
Lord Mfg. Co.
Erie, Pa.

Elastomeric torsion spring for tractor seat uses castellated inside tube to simplify mounting in assembly.

ELASTOMERIC torsion springs permit angular motion along with relatively fixed positioning in other modes. This characteristic often obviates the need for bearings and seals at mechanical joints requiring limited angular travel. At the same time such springs retain a slight cushioning effect in all directions.

The effectiveness of rubber-like materials used in torsion-spring applications is due principally to their ability to distribute stresses uniformly throughout a large section. This property also provides resistance against shock or momentary overload. In tests, elastomeric torsion springs have stored momentary energy to 80,000 lb-in. per lb of elastomer at 2000 psi shear. Service uses, however, usually do not exceed 20 per cent of these extreme laboratory figures.

Basic Concepts

A typical elastomeric torsion spring, Fig. 1, comprises a metal inner shaft or tube, a tubular-metal outside shell, and a cylindrical mass of an elastomer between and bonded to both metal elements. Twisting either the shaft or shell relative to the other distorts the elastomer against elastic restraint.

*Formerly Chief Development Engineer, B. F. Goodrich Co., Akron, Ohio.

Fig. 2 — Stress-strain curve for 40-durometer elastomeric material. Slope at 150 per cent shear determines nominal shear modulus, G. For this stock, $G=54$.

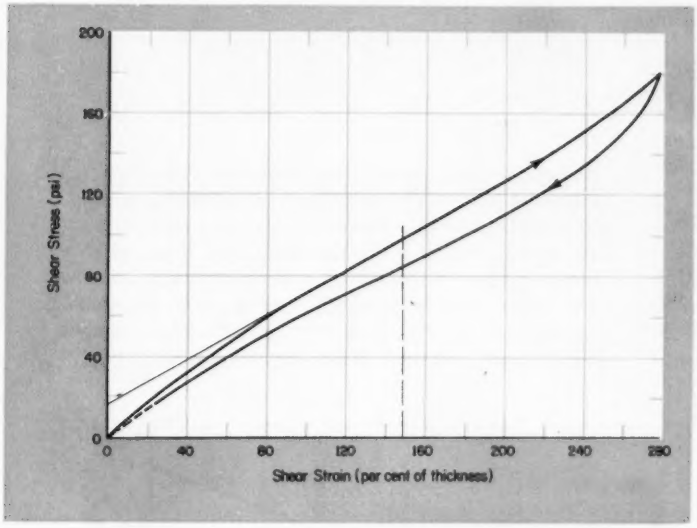
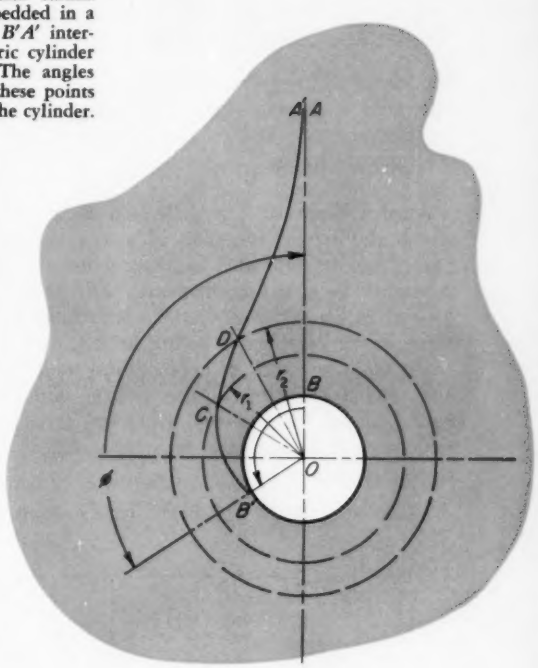


Fig. 3—General form of polar-strain diagram. Radial line BA is distorted to $B'A'$ as shaft, embedded in a large mass of elastomer, is rotated. Line $B'A'$ intersects radii r_1 and r_2 of a sample elastomeric cylinder (shown in dashed lines) at C and D. The angles formed by $B'A'$ and radial lines through these points measure shear strain at the ID and OD of the cylinder.



In simple rotation, any cylindrical element of the elastomer is in shear. Unit shear stress in a cylindrical element of thickness Δr, Fig. 1, varies inversely as the square of the radius, r, to that element. This factor has a leveling influence on design. That is, when the wall thickness of a given spring is increased, the added material is stressed less highly than the material at less radius and contributes less per unit volume to the total energy absorbed or stored. Thus, increasing the wall thickness of an elastomeric spring can result in a diminishing return of usable energy. Torsion springs with wall thicknesses over 50 per cent of their ID are unusual.

Polar Strain: Since a stress-strain curve for an elastomer in pure shear is not a straight line, Fig. 2, some form of integration is necessary to translate a laboratory curve for pure shear into a loading curve for a torsion spring. This transition is aided by the polar-strain concept, which can be demonstrated by showing a shaft embedded in a large mass of rubber-like material, Fig. 3. Line BA, radial before rotation, assumes the shape of $B'A'$ after the shaft is rotated through angle ϕ. Line $B'A'$ approaches BA asymptotically. The angle that line $B'A'$ makes with a radial line from O measures shear strain in a cylindrical element at that radius.

In practice, laboratory tests of a stock in pure shear, Fig. 2, are translated directly into a polar-strain curve, Fig. 4, by integrating the stress from the shaft surface to infinity.[1] Table 1 correlates shear moduli G and hardnesses of typical elastomeric stocks.

The family of polar-strain curves is then used to plot a static-load deflection curve, Fig. 5, for a specific torsion-spring application. The curve shown represents a 45.5 durometer stock ($G = 72$) with a 6 in. ID and a 10.2 in. OD. A shear stress of 100 psi on the ID corresponds to a stress on the OD of $100(6/10.2)^2 = 34.6$ psi. From the curve for $G = 72$, Fig. 4, a 100 psi stress produces a de-

[1]References are tabulated at end of article.

Table 1—Shear Modulus of Elastomers

Shore Durometer	Shear Modulus, Static*	Shear Modulus, Dynamic†	Modulus Ratio (Dynamic to Static)
40	54	65	1.2
42.5	62.4	78	1.25
45.5	72	93.5	1.3
49	83	112	1.35
52	96.5	135	1.4
55.5	112	162	1.45
59	130	194	1.5

*Static data taken at 150 per cent shear strain; 0.01 cps.
†Dynamic data taken at 150 per cent shear strain; 2 cps.

flection of 29 deg; a 34.6 psi stress, 9 deg. The difference — 20 deg — represents the windup that corresponds to a 100 psi shear stress on the ID of the example spring.

Axial Deflection: Tilt deflection is the angle by which the axis of the shaft of a torsion spring departs from its unloaded position when the shaft is subjected to a tilting moment. Tilt rate Q (expressed in.-lb per deg) varies approximately as the third power of effective spring length, directly with shaft diameter and shear modulus, and inversely with radial thickness of the spring. Tilt rate can be calculated for a given cylindrical torsion spring with the aid of empirical tilt curves, Fig. 6. To use these curves:

1. Calculate $[(R/r) - (3/2)]^{1/3}$ for the given torsion spring, where R = outer radius, in.; r = inner radius, in.
2. Calculate $[(L - R)/r]^{1/3}$, where L = length, in.
3. Plot the point on Fig. 6 represented by the values calculated in Steps 1 and 2. Determine the value of constant k, using linear interpolation between the curves.
4. Solve for Q from

$$Q = \frac{r^2 L^2 G}{k(R - r)} \qquad (1)$$

Values of Q taken from practical designs for production may vary from several hundred-thousand pound-inches per degree for a relatively large and long spring to less than 100 lb-in. per deg for a mounting for the shaft of a control mechanism which must provide relatively easy tilt. If the tilt is continuous, or if its cycle is frequent (in the range of several per minute), the fatigue life of a spring

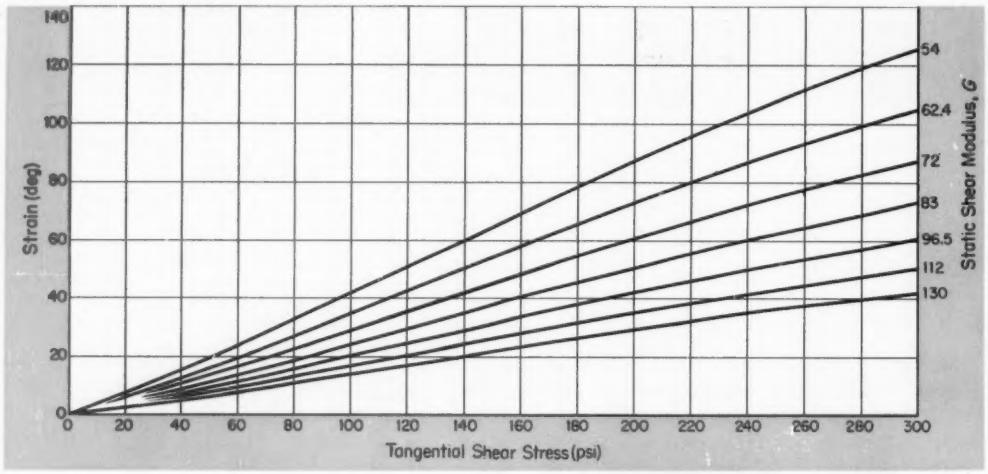


Fig. 4 — Static polar-strain curves for cylindrical torsion springs.

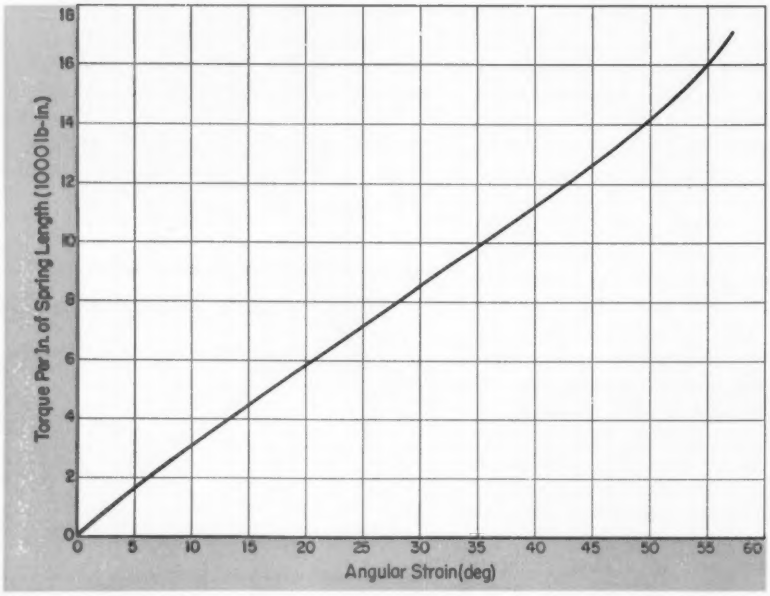


Fig. 5—Static-load deflection curve for normal stress range of 45.5-durometer stock with 6.0-in. ID, 10.2-in. OD.

will be reduced. Tilt which produces less than 10 per cent maximum change in radial wall thickness generally does not reduce fatigue life significantly.

Both tilt and changes in tilt may have an adverse effect on the life of an elastomeric torsion spring. The torque arm or loading device should be located so that these effects are minimized. Where a high tilt moment is unavoidable, the use of a steady-rest bearing can often improve tilt resistance of an assembly. This bearing itself can be a small elastomeric bushing.

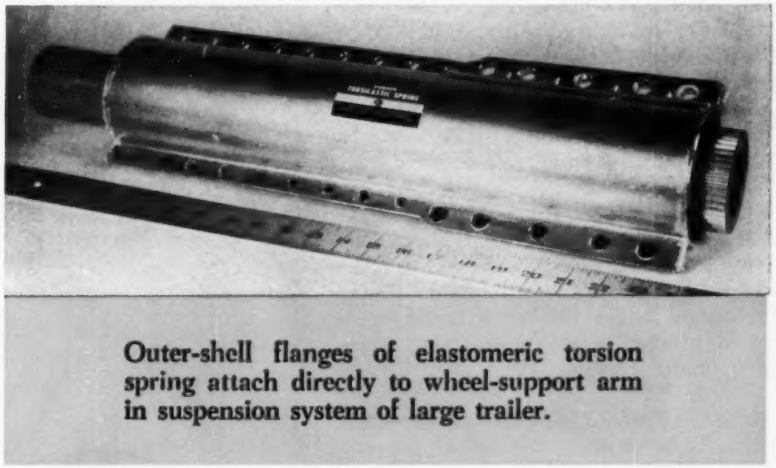
Axial Movement: An elastomeric torsion spring can move axially to a considerable amplitude. As a rough guide, axial movement as great as the wall thickness of the elastomer is well within permissible stress. Elastic resistance to axial movement is equal to shear stress times the area of an equivalent flat shear sandwich. Effective area can be taken as the cylindrical surface at the mean radius of the elastomer. Sandwich thickness is the radial thickness of the elastomer.

Radial Movement: The radial deflection of a bonded torsion spring under load is approximately equivalent to the elastic compression of a sandwich whose load-supporting area, $A_L = (3/2)dL$, where d = ID of the elastomer; L = its effective length. Approximate bulge area A_B can be found from

$$A_B = \frac{2}{3}\left[\, 2a + L(D - d) \,\right] \qquad (2)$$

where D = OD of the elastomer; a = total exposed area of one end.

Allowable radial deflection depends mainly on the oscillation frequency. Torsion springs usually are designed so that radial deflection does not exceed



Outer-shell flanges of elastomeric torsion spring attach directly to wheel-support arm in suspension system of large trailer.

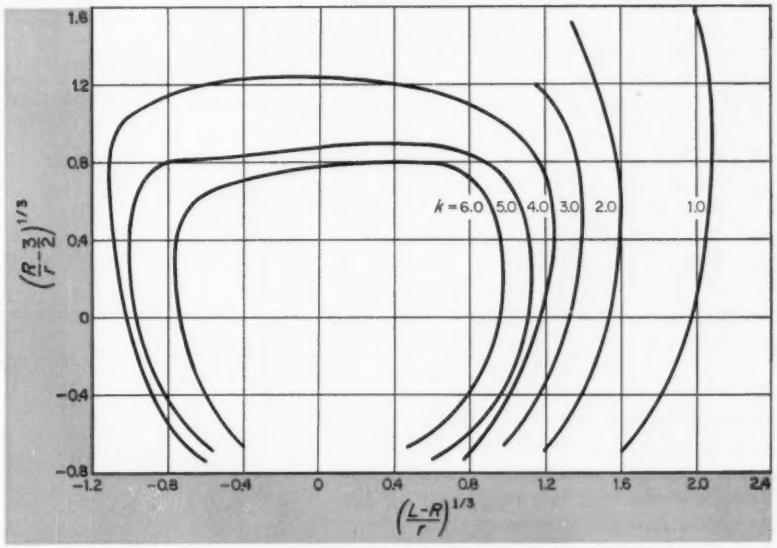


Fig. 6—Empirical tilt curves for cylindrical torsion springs.

10 per cent of their wall thickness, although when they are used as elastic bearings or bushings, greater deflections are permissible.

Design Considerations

For best over-all performance and minimum creep characteristics, bonding of the elastomer on both the ID and OD is recommended.

Shrinkage: Although fully bonded torsion-spring construction offers many service advantages, the inherent problem of shrinkage during manufacturing must be met. The volume of most elastomers changes approximately 0.023 per cent per deg F, or a total reduction of about 5 per cent from curing temperature to room temperature. However, other partially compensating volume-change effects exist, and it is common practice to allow for about 3.5 per cent shrink after cure. Where an elastomer is bonded over a considerable area to a metal which cannot move, and where the exposed elastomer area is relatively small, even this small amount of shrinkage may cause a damaged bond, voids, or unrelieved tensile stresses in parts of the body.

Some differences of opinion exist among authorities on the effect of tensile stresses produced during cooling. Uncorrected cooling tension is generally harmful and can result in a 20 to 50 per cent reduction in fatigue life for a torsion cycle (as compared to that of the same spring where the body is under compression).

Split Shells: The outer shell of a bonded torsion spring is often split to retain the desired compression at the bonded surface. Any number of splits may be used—two being the most common, Fig. 1. This construction permits the outer shell to decrease in diameter during cooling and thereby corrects for shrink of the elastomer.

A few of the many commonly used methods of holding split outer shells in position are shown in Fig. 7. When a 2-piece shell is used, the split need not divide the circumference into two equal halves. Nor need the OD of the elastomer be cylindrical, although sudden or extreme deviations from a cylindrical shape should be avoided.

A further decrease in diameter at assembly is often desirable. This puts the body of elastomer under compression, increasing fatigue life, and avoids possible loosening of the elastomer from the shell at low temperatures.

End Contour: The body of an elastomeric torsion spring should have a minimum thickness of 1/32 in. where its end joins the metal parts. Concave end contours can be made with two radii, Fig. 8. The dotted line shows how the elastomer should bulge under compression—which should not be sufficient to cause the contour to become convex.

In assemblies where the elastomeric spring is pressed into a tubular housing, commercial-tubing ID limits may be too wide to produce consistently the required compression, particularly in long, thin-walled springs. In such instances, the spring is often made slightly elliptical, and the major axis is assembled in the plane containing the keys.

Stresses: Design limitations of torsion springs depend greatly on the type of service involved. For example, static stress in shear at the ID may be as low as 25 psi for 40 durometer stock used in supporting a machine or instrument; it could be 150 psi or more for maximum static load in a bus suspension.

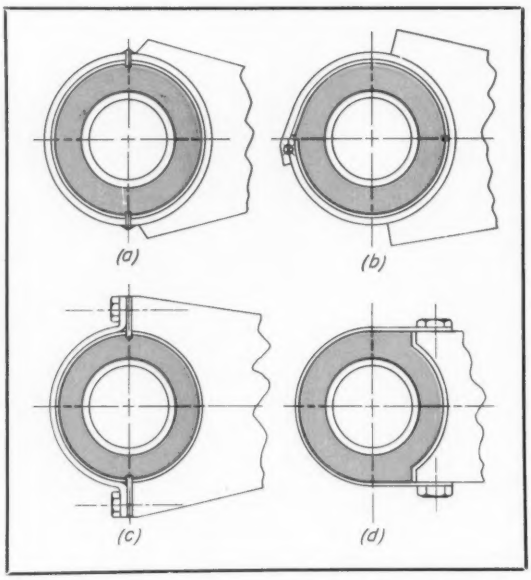


Fig. 7—Mounting arrangements for elastomeric torsion springs. Discontinuous or intermittent keys, *a*, are welded to tubular housing or formed as integral part of housing. Single-direction key, *b*, is produced by wrapped housing. Loose keys, *c*, are placed under retainer caps. Tangential band, *d*, retains noncylindrical spring which requires no keys.

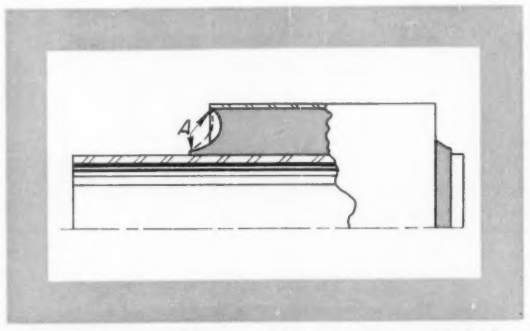


Fig. 8—Proper end-contour design for elastomeric body. Shoulders at *A* should be 1/32 in. minimum. Dotted line shows contour under radial compression.

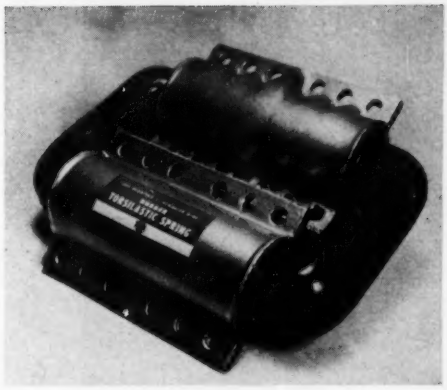
Reduction of service stress is only partially effective in reducing creep. Theoretically, creep should be a percentage of nominal deflection over a wide range of stress. In practice, however, the percentage of creep increases slightly with stress, particularly in the high-stress range.

Stress range has a much greater effect than mean stress on fatigue life,[2] and any rate of working sufficient to heat the body will shorten its life. Extremely high overload or impact can be taken either in rotation or in the other modes of motion if these loads do not occur frequently.

Shear modulus *G*—a measure of stiffness—for an elastomeric material increases at higher stress ranges. For this reason, when redesign of a part is attempted for weight, size, or cost reduction, calculations for a more highly stressed spring often show that the revised spring must be made with thicker walls, and the end result is a spring as bulky as before.

In general, the stress on the inner shaft is the limiting factor in design proportions. A preliminary balance is first established between spring length and shaft diameter, starting near the upper limit of a convenient length. The smallest shaft diameter which will give the required static shear on the ID of the elastomer is then calculated. Since this procedure frequently indicates a shaft too small for the required metal stresses, an adjustment is made accordingly.

All torsion springs of the same elastomer will wind up to the same angle at the same ID shear stress if the radial wall is the same percentage of the ID. Therefore, making the shaft diameter as small as possible keeps the over-all size of the spring assembly to a minimum.



Double torsion-spring assembly is used as a shackle in truck suspension system. Assembly links arm of larger torsion spring to chassis.

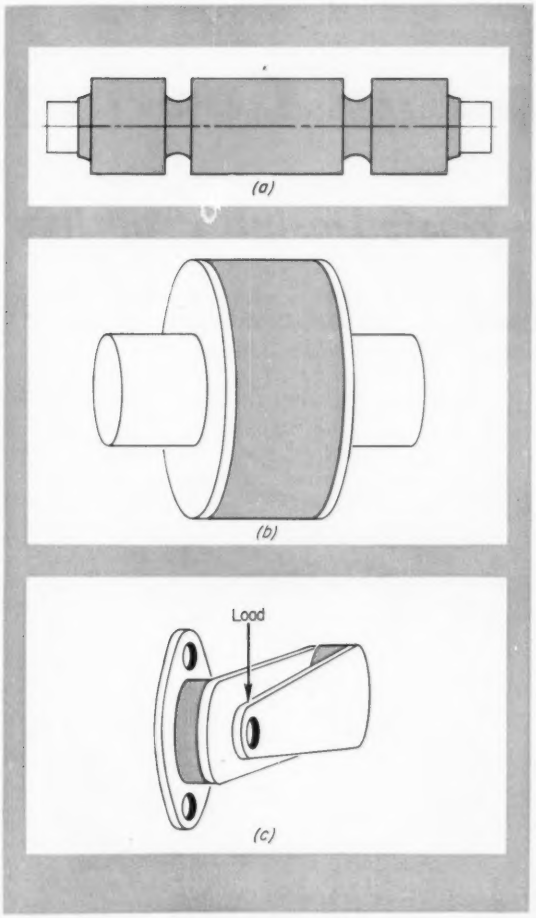


Fig. 9—Common variations in cylindrical torsion springs. Series spring, *a*, accommodates extremely high angular deflections; column-type spring, *b*, also takes high angular deflection, but is not practical for precise applications; combination *c* provides an extremely soft mounting, frequently required for miniature parts.

Variations: Rubber springs bonded only on the ID have characteristics similar to fully bonded springs. The OD of the elastomer is left large so that it can be reduced at assembly. The amount of possible distortion, in terms of per cent of radial wall, depends on spring length because the displaced material must flow to the ends. Assembly distortion can vary from less than 10 per cent for moderately long springs to 40 per cent for short springs.

Torsion springs sometimes are made without bonding either the ID or OD. In these cases, the free slug of rubber is usually made with a hole appreciably smaller than its assembled ID and with an OD larger than the assembled OD. Free length, of course, must be less than that of the finished part since the volume remains constant. In service, this type of spring is inferior to the bonded type, particularly because it lacks the means to hold a required angular position.

Various modifications and combinations of cylindrical torsion-springs are used for applications requiring high angular deflection, Fig. 9*a* and *b*, or an extremely soft mounting, Fig. 9c.

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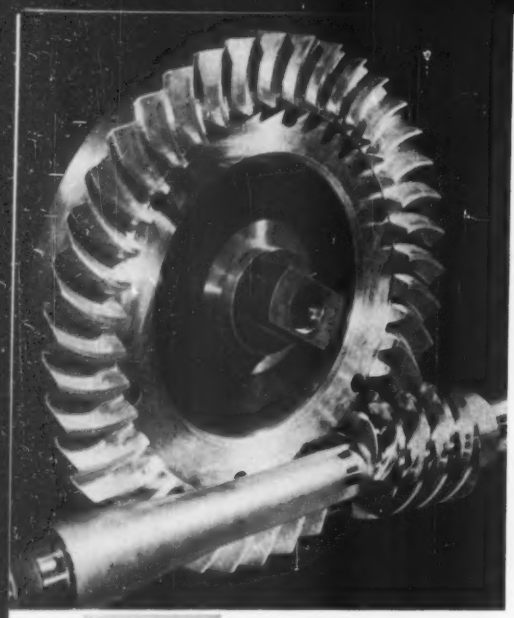
1. C. W. Harris, "Polar Strain," *Journal of Applied Mechanics*, Vol. 14, June, 1947.
2. A. S. Krotz, "Elastomers." MACHINE DESIGN, Vol. 32, No. 24, November 24, 1960, pp. 146-154.



Spiroid skew-axis type gearing is based on an established design concept: Tapered pinions with constant lead threads mesh with face-type gears. Typical gear designs shown here represent practical extremes in ratio range. The coarse-pitch power gears operate at 10.25:1 reduction while the fine-pitch, high-precision gear set develops a 359:1 ratio in a single mesh.

Characterized by high-contact ratios, relatively low sliding velocities, and sensitive backlash control, Spiroid gears can be adapted to a broad range of drive requirements in the medium to high-reduction ratio range. Details of their design and application are presented in this series of articles.

In this first part, general operating characteristics, gear geometry, and blank proportions are covered. Succeeding parts will deal with strength and durability ratings, efficiencies, mounting design, tolerances, and application factors.

Spiroid Gearing

Part 1—Basic Design Practices

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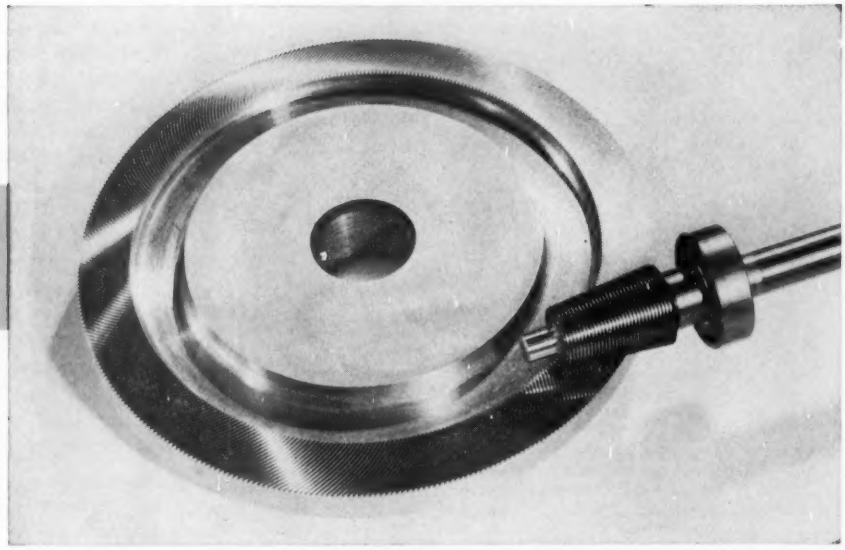
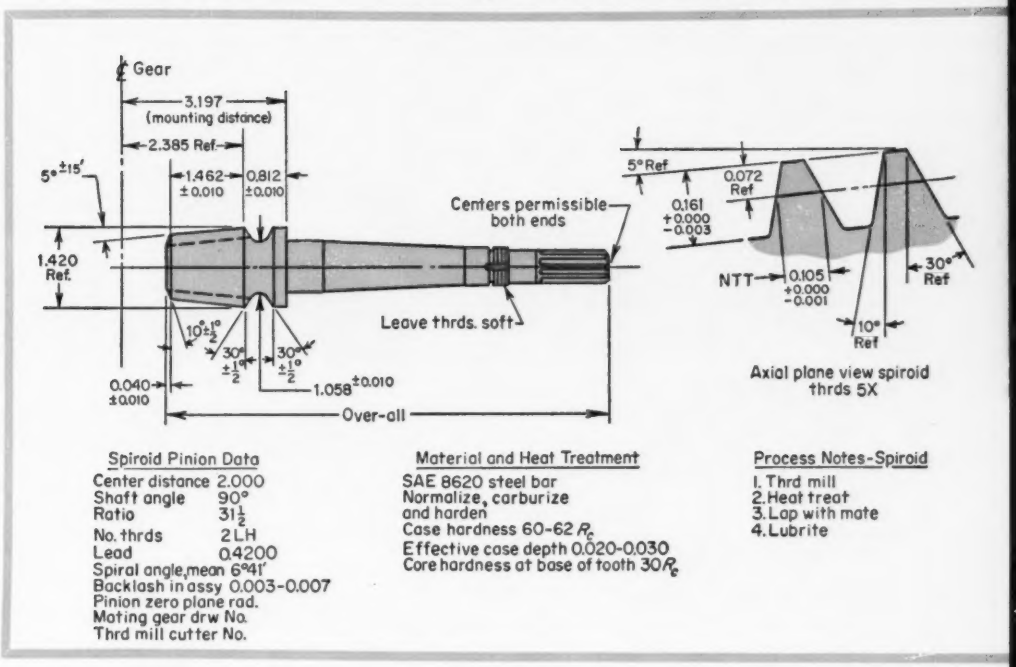


Fig. 1—Typical detail drawing of Spiroid pinion.



A SPIROID pinion is a frustum of a right circular cone with one or more threads of constant lead, Fig. 1. The enveloping cone is the pitch surface. It is called the primary pitch cone because the pinion is the defining member of the gear pair. Pinion outside diameter, d_o, is the largest diameter of the cone frustum. A cone taper of 5 deg with respect to the pinion axis is generally recognized as standard.

The gear, Fig. 2, has spiral teeth. A face angle of 8 deg is standard for mating with a pinion of 5-deg taper. The gear pitch surface, which is not conical, is an envelope of the primary pitch cone of the pinion. Teeth are generated in the gear by a hob that is the counterpart of the pinion.

General Characteristics

Practical design of a Spiroid gear pair generally concludes with two detail drawings, one of the tapered pinion, or thread member, and the other of the gear. Fig. 1 and 2 are abbreviated detail drawings of a pinion and its mate.

Fill-in tracings are a quick and adequate method of making drawings of the engagement portions of the gears. They can be complete detail drawings of parts if space is also available on the tracings for showing other design details, such as pinion shanks, gear hubs, securing devices, bearing areas, and shoulders.

Gear-Ratio Range: Reduction ratios as great as 360:1 from a single Spiroid gear mesh are practical. The lower limit of reduction ratio is 10:1. Normally, the pinion is the driver but gear-pair efficiencies are high enough in the lower ratios so that either member can be the driver. Pinions usually have from one to six threads.

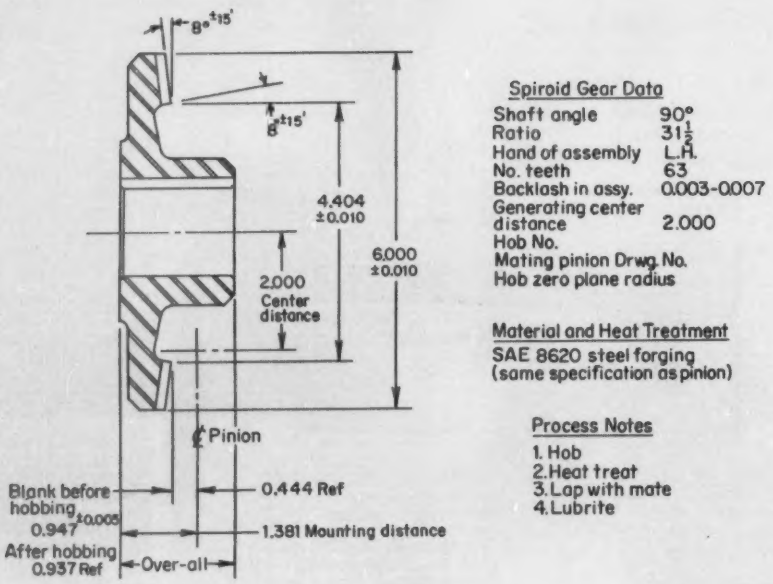
Pressure Angles (Axial): Opposite profiles of a pinion-thread have different pressure angles. The smaller, or low-side, pressure angle, is 10 deg if the pinion spiral angle is less than 16 deg, and 15 deg when the spiral angle is 16 deg and larger.

High-side pressure angles are 30 and 35 deg. The larger angle is used if necessary to avoid undercut on the gear teeth. Fig. 3 illustrates these axial pressure angles along with other thread proportions. Symbols are defined in the Nomenclature.

Geometry

Spiroid gears are based upon exact Mathematical concepts* which only recently have been sufficiently

*O. Saari—*Mathematical Background of Spiroid Gears*, Industrial Mathematics Series, Detroit-Wayne State University Press, Detroit, Mich., 1956.



Spiroid Gear Data

Shaft angle	90°
Ratio	31½
Hand of assembly	L.H.
No. teeth	63
Backlash in assy.	0.003-0.007
Generating center distance	2.000
Hob No.	
Mating pinion Drwg. No.	
Hob zero plane radius	

Material and Heat Treatment

SAE 8620 steel forging
(same specification as pinion)

Process Notes

1. Hob
2. Heat treat
3. Lap with mate
4. Lubrite

Fig. 2 — Typical detail drawing of Spiroid gear.

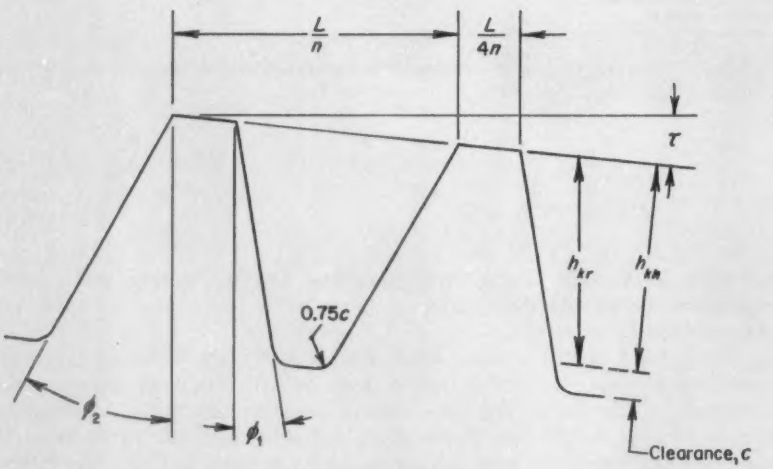


Fig. 3 — Pinion thread proportions in axial plane at taper angle τ.

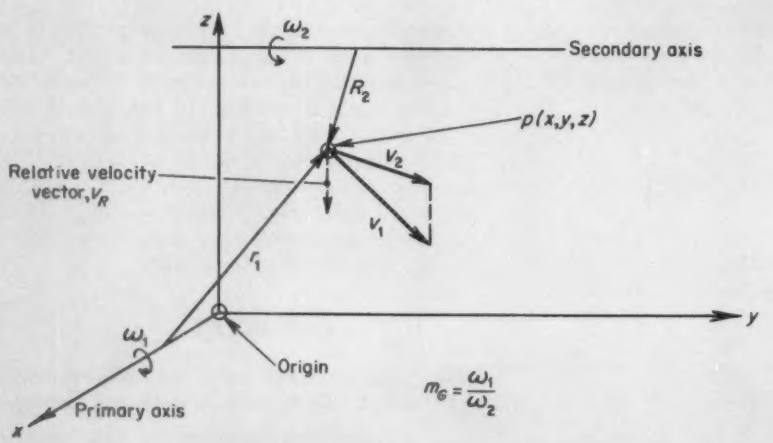


Fig. 4 — Relative-velocity vector as a point function.

Gear Classes

Shaft orientation divides toothed gears into classes and is a primary reason for the variety of tooth shapes. Shafts can be parallel, intersecting, or skewed (neither parallel nor intersecting).

Tooth profiles on gears for operation on parallel shafts are almost always involutes of circles. Thus, parallel shafts and involute teeth characterize spur and helical gears. Teeth on gears for operation on intersecting shafts, though never true involutes, look and perform like involute teeth. Intersecting shafts are the common class characteristic of bevel gears but inability to manufacture the spherical involute with precision has led to a host of general-purpose and special tooth forms, and influenced classification.

Whereas spur gears accommodate center distance and bevel gears accommodate shaft angle, gears for operation on skewed shafts must accommodate both center distance and shaft angle. No single type of skew-axis gearing is suited to all of the possible combinations of center distance and shaft angle. Hence, selection of a specific gear pair is strongly influenced by shaft relationships.

Exclusive of crossed helical gears, skewed shaft angles of 90 deg are generally taken for granted. This custom greatly simplifies design calculations, eases the difficulties of manufacture and mounting, and offers the greatest promise of satisfactory gear service. Accordingly, gear design is generally based on right-angle gears over a range of center distance.

This center-distance range is bounded by the bevel gear with zero center distance and the worm gear with maximum center distance. Between these extremes, proprietary gear forms, such as Spiroid, and hypoids fill in the gap. Thus, a broad range of right-angle gear types is available to fit the requirements of any center distance.

generalized to guide the design of a constant-lead system of mating tapered pinions and face-type gears.

The first important concept is: Given two skewed axes (not necessarily at 90 deg shaft angle), a speed ratio between the axes, and a mathematical system of co-ordinates for reference, there exists a unique relative-velocity vector for every point in the co-ordinate system. Thus, this relative-velocity vector, or total sliding-velocity vector as it is sometimes called, is a point function, Fig. 4. Further, this point function has a system of "field lines" or a family of space curves which are everywhere codirectional with the vectors of the field.

Another important concept is that of the "ideal tooth curve." Basic conditions are, Fig. 5:

1. Two skewed axes have a center distance C and a shaft angle of 90 deg.
2. One axis contains the primary pitch cone of arbitrary position and taper angle.
3. The speed ratio between the two axes is $m_G = \omega_1/\omega_2$ where ω_1 = primary pitch cone speed and ω_2 = conjugate pitch surface speed.

The primary pitch cone defines a conjugate pitch surface of revolution, about the secondary axis. This conjugate surface is not a cone. The most intimate approach of these two pitch surfaces is a curved line. This line is the locus of all points of tangency of the pitch surfaces and is called the "pitch-contact locus," Fig. 6.

Relative-velocity vectors for all points on the pitch-contact locus are completely defined since they are point functions, Fig. 4. Fig. 6 shows, pictorially, vector subtraction to find the relative-velocity vector at an arbitrary point p on the pitch-contact locus.

When the directions of the relative-velocity vectors are known at every point on the pitch-contact locus, it is possible to describe a spiral-type curve on the primary pitch cone, Fig. 7. This spiral trace is codirectional with the relative-velocity vectors on the pitch-contact locus.

To see this a little more clearly, suppose the primary pitch cone were rotated with the spiral trace fixed to it. Then, every point of the trace would, at some time, intersect the pitch-contact locus. Every point on the spiral trace, therefore, has a corresponding point on the pitch-contact locus. Because of this one-to-one correspondence, the direction or slope of the spiral trace is completely determined by the relative-velocity vectors on the pitch-contact locus. A spiral trace so defined is an ideal tooth curve.

For a consistent set of pitch surfaces and spiral traces, the fundamental question is: What shape of the pinion threads will result in the maximum extent of conjugate tooth action? Improperly chosen threads result in mating generated gear teeth with large inactive fillets or undercuts on their working flanks. This, of course, means structurally weaker

teeth and loss of effective contact line for load carrying.

If the trace of the chosen thread shape is similar to the ideal tooth curve, Fig. 7, conjugate action will exist at every point along the pitch-contact locus. It has been found that the ideal tooth curve can be very closely approximated by a tapered spiral of constant lead. A mechanical motion such as this can be easily produced on existing machine tools, such as thread mills, chasing lathes, and thread grinders, with slight modifications. Spiroid pinions are made by such processes.

Lead: Another question of importance is: How is the lead of the tapered spiral which approximates the ideal tooth curve calculated? Position co-ordinates of the pitch-contact locus may be computed

Nomenclature

a = Distance along pinion axis between pitch cone apex and common perpendicular to gear and pinion axis, in.
C = Center distance, or offset, in.
c = Clearance, in.
d_o = Pinion outside diameter, in.
F = Face width of pinion, in.
h_{kn} = Working depth normal to thread tips, in.
h_{kr} = Working depth perpendicular to pinion axis, in.
L = Conical lead of pinion, in.
m_G = Gear ratio
= N/n
N = Number of teeth on gear
n = Number of threads on pinion
R_G = Pitch radius of gear, in.
R_i = Point radius of gear, in.
R_o = Outside radius of gear, in.
r = Any pinion radius, in.
r_i = Intercept of element of pinion pitch cone with center distance (zero plane radius), in.
r_m = Mean radius of pinion at midface and at half the working depth, in.
r_o = Largest radius of pinion pitch cone, in.
r_p = Pitch radius of pinion, in.
x_L = Distance along pinion axis between cone section of largest diameter and common perpendicular to gear and pinion axis, in.
x_m = Co-ordinate to plane of mean radius of pinion, in.
y_h = Distance along gear axis between tips of teeth at point radius R_i and common perpendicular to gear and pinion axis, in.
α = Angular co-ordinate of pitch point on pinion (Fig. 9), deg
σ = Pitch-point location angle on gear (Fig. 10), deg
τ = Angle between an element of pinion-pitch cone and pinion axis, deg
τ_G = Angle between an element of gear-blank face and a perpendicular to the gear axis, deg
ϕ_1 = Tooth axial pressure angle (low side), deg
ϕ_2 = Tooth axial pressure angle (high side), deg
ϕ_2' = Critical pressure angle (high side), deg
ψ_m = Mean spiral angle of pinion, deg
ω = Angular velocity rad/sec

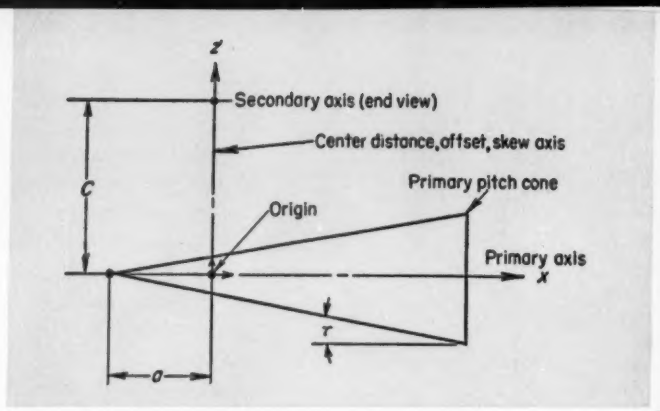


Fig. 5—Position of secondary (gear) axis, relative to primary pitch cone and pinion axis.

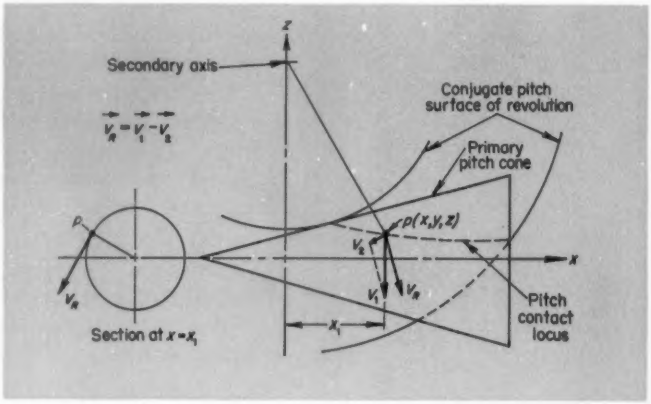


Fig. 6—Pitch-contact locus and relative-velocity vector.

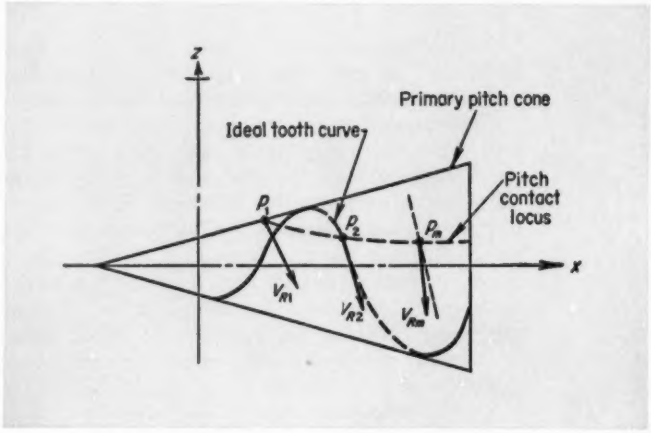
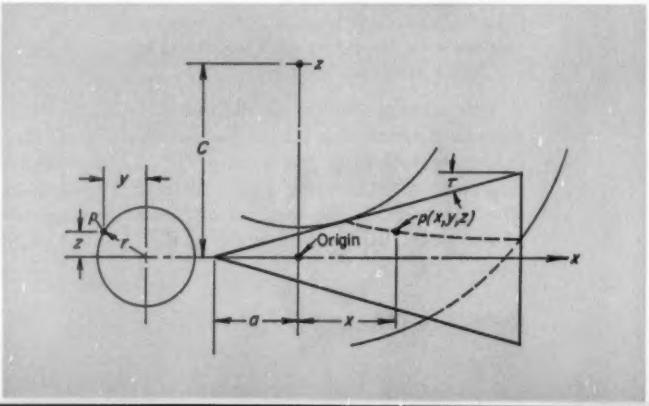


Fig. 7—Ideal tooth curve which is codirectional with relative-velocity vectors along pitch contact locus.

Fig. 8—Optional parameters for definition of conical lead equation.



when a, τ, and C are given, Fig. 8. For any x co-ordinate, r, z, and y values are

$$r = (a + x)\tan\tau \tag{1}$$

$$z = \frac{C}{1 + \dfrac{x}{r\tan\tau}} \tag{2}$$

$$y = \sqrt{r^2 - z^2} \tag{3}$$

When the speed ratio, $m_G = N/n$, is specified, the lead of the ideal tooth curve at any x co-ordinate on the pitch contact locus is:

$$L = \frac{2\pi(C - z)}{\dfrac{N}{n} - \dfrac{xy}{r^2}} \tag{4}$$

Lead L should be thought of as the rate of axial movement for 2π radians of angular movement of a point traveling along the path of a spiral curve on the primary pitch cone. It is apparent that the value of lead depends on the x co-ordinate chosen, once the pitch surfaces are fixed and the speed ratio is given.

Conversion of the x, y, z co-ordinates of Fig. 8 to angle parameters, α and σ of Fig. 9, is desirable for design purposes. Accordingly,

$$x = R_G \sin\sigma \tag{5}$$

$$y = r_P \cos\alpha \tag{6}$$

$$z = r_P \sin\alpha \tag{7}$$

When Equations 5, 6, and 7 are substituted into Equation 4,

$$L = \frac{2\pi R_G \cos\sigma}{\dfrac{N}{n} - \left(\dfrac{R_G}{r_P}\right)\sin\sigma\cos\alpha} \tag{8}$$

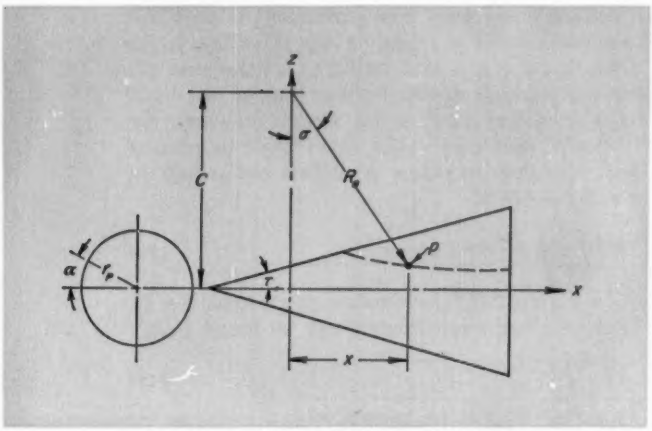


Fig. 9—Standard parameters for definition of conical lead equation.

Tooth Data and Blank Proportions

Experience has proved that the best location for the primary pitch cone is the outside cone of the pinion threads; that is, the cone containing the tips of the threads. In this position the maximum degree of conjugate tooth action is obtained on the mating gear, since the approximate ideal tooth curve lies near the root of the gear teeth, Fig. 10.

Pitch Point: That point on the pitch-contact locus, upon which the lead is based, is called the pitch point. Subscript p is used here to identify pitch point co-ordinates. Location of the pitch point has an important effect upon the extent of conjugate action. In general, the pitch point should lie in the inner third of the gear face.

Ratio of the pitch radii of the gear and pinion at the pitch point, R_G/r_P, controls the relative sizes of pinion and gear. Fig. 11 charts design curves of R_G/r_P as functions of center distance C and numbers of teeth N of the gear. Minimum and maximum

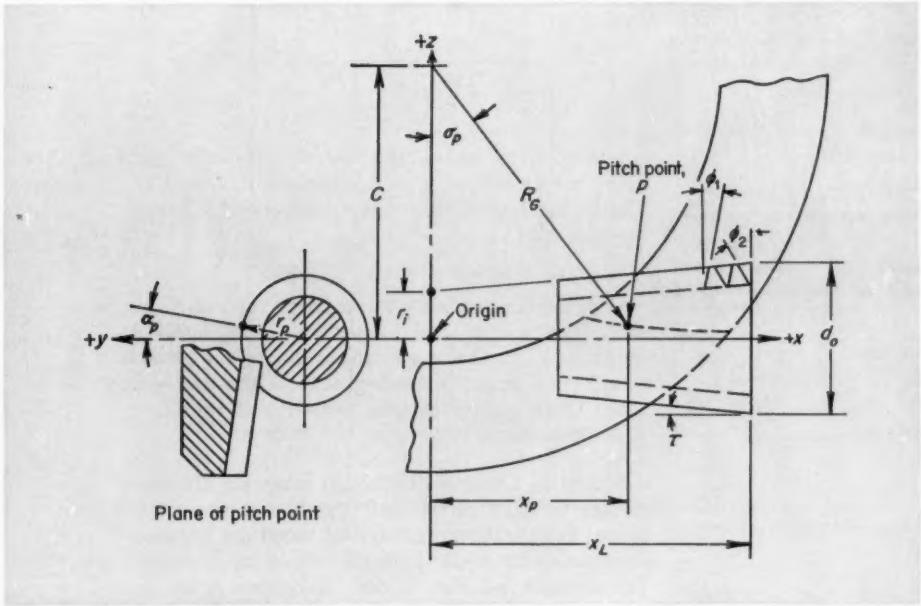


Fig. 10—Gear-pair design parameters.

numbers of gear teeth for each center distance can be read directly from Fig. 11. A hunting tooth ratio is desirable, when possible; that is, make the number of teeth in the gear a prime number with respect to the number of threads in the pinion.

Standard Pitch-Point Angle: Offset or center distance between the axes of pinion and gear is a function of σ angle. In general, low ratios and extra large pinions have large angles σ, while high ratios and small pinions have small angles σ. These angles can range from approximately 30 to 60 deg. For general-purpose design, $\sigma = 40$ deg is taken as standard. This angle gives a gear outside diameter of three times the center distance.

Other blank proportions to conform with $\sigma = 40$ deg are shown in Fig. 12.

Also, from Fig. 10

$$\sin \alpha_p = \frac{\tan \tau}{\tan \sigma_p}$$

$$= \frac{0.0875}{0.8391} = 0.1041 \qquad (9)$$

where $\tau = 5$ deg and $\sigma = 40$ deg are used as standard. The pitch radius of the pinion is

$$r_P = \frac{C}{\sin \alpha_p + \left(\frac{R_G}{r_P} \right) \cos \sigma_p}$$

$$= \frac{C}{0.1041 + \left(\frac{R_G}{r_P} \right) (0.7660)} \qquad (10)$$

The corresponding pitch radius of the gear is $R_G = r_P$ (ratio R_G/r_P).

Pinion Taper and Dimensions: Good design practice places the pinion taper angle between 5 and 10 deg for most general applications. For standardization and ease of manufacture, 5 deg is chosen. Naturally, this does not preclude the use of other angles, which may be necessary sometimes.

When any other angle of pinion taper is selected, these conditions should be kept in mind:

1. Excessive taper angle tends to decrease the effective load-carrying face width and presents manufacturing difficulties.
2. Too small a taper angle tends to limit the extent of conjugate action, thus decreasing the gear face width and power capacity.

Where a taper angle greater than 5 deg is used, the gear face angles also need to be increased. For 7 and 10 deg pinion tapers, gear face angles of 11 and 14 deg are recommended.

From Fig. 10,

$$r_i = r_P - R_G \sin \sigma_p \tan \tau \qquad (11)$$

Thus, the pinion outside diameter at the large end can be found from

$$d_o = 2(r_i + x_L \tan \tau) \qquad (12)$$

where x_L of Fig. 10 may be scaled from a layout for a general case or taken from Fig. 12 for standard proportions.

Now, the tooth proportions of Fig. 3 may be found from

$$h_{kr} = \frac{0.5 \left(\frac{L}{n} \right) \sec \tau}{\frac{\sin \phi_1}{\cos(\phi_1 + \tau)} + \frac{\sin \phi_2}{\cos(\phi_2 - \tau)}} \qquad (13)$$

$$h_{kn} = h_{kr} \cos \tau \qquad (14)$$

$$c = 0.07 \left(\frac{L}{n} \right) + 0.002 \qquad (15)$$

where lead L is given by Equation 8.

Spiral Angle: The pinion spiral angle is defined as the angle between the tangent to the spiral trace of the thread surface and the normal to the cone element passing through the point of tangency. Spiral angle varies with pinion radius. Pitch radius spiral angles are used in approximate efficiency calculations. Cutter or grinding wheel setting angles match spiral angles at a radius to a point near the midface working depth. Pressure angles are based on mean radius spiral angles. Design drawings, Fig. 1, include the mean radius spiral angle as primary data. Mean pinion radius at midface and at half the working depth is

$$r_m = r_i - \frac{h_{kr}}{2} + x_m \tan \tau \qquad (16)$$

where $x_m = 0.827\,C$ for standard proportions, Fig. 12. Thus, the mean spiral angle can be found from

$$\tan \psi_m = \frac{L \sec \tau}{2 \pi r_m} \qquad (17)$$

If ψ_m is less than 16 deg, a low-side pressure angle of 10 deg is used. Otherwise a pressure angle of 15 deg is used.

To check the high-side pressure angle for undercut, the critical or limit pressure angle is found from

$$\tan \phi_2' = \frac{r_P}{x_p} \div \frac{C z_p}{r_P \left(\frac{N y_p}{n} - x_p \right)} \qquad (18)$$

where x_p, y_p, z_p, and r_P, the co-ordinates of the pitch point, are calculated from Equations 5, 6, 7, and 10. The high-side pressure angle, ϕ_2, is selected to satisfy the condition,

$$\phi_2 \geq (\phi_2' + 5) \text{ deg} \qquad (19)$$

If $\phi_2' + 5$ exceeds 35 deg, a larger ratio of R_G/r_P should be selected and proportions recalculated. A larger R_G/r_P results in a smaller pinion and a greater mean spiral angle. Increasing angle σ also decreases offset. Both values can be modified, if necessary, to avoid undercut.

Mounting Distances: Although mounting distances cannot be fully established from tooth proportions alone, those components of total mounting distances determined by tooth proportions can be indicated. For example, x_L, Fig. 10 and 12, defines pinion lo-

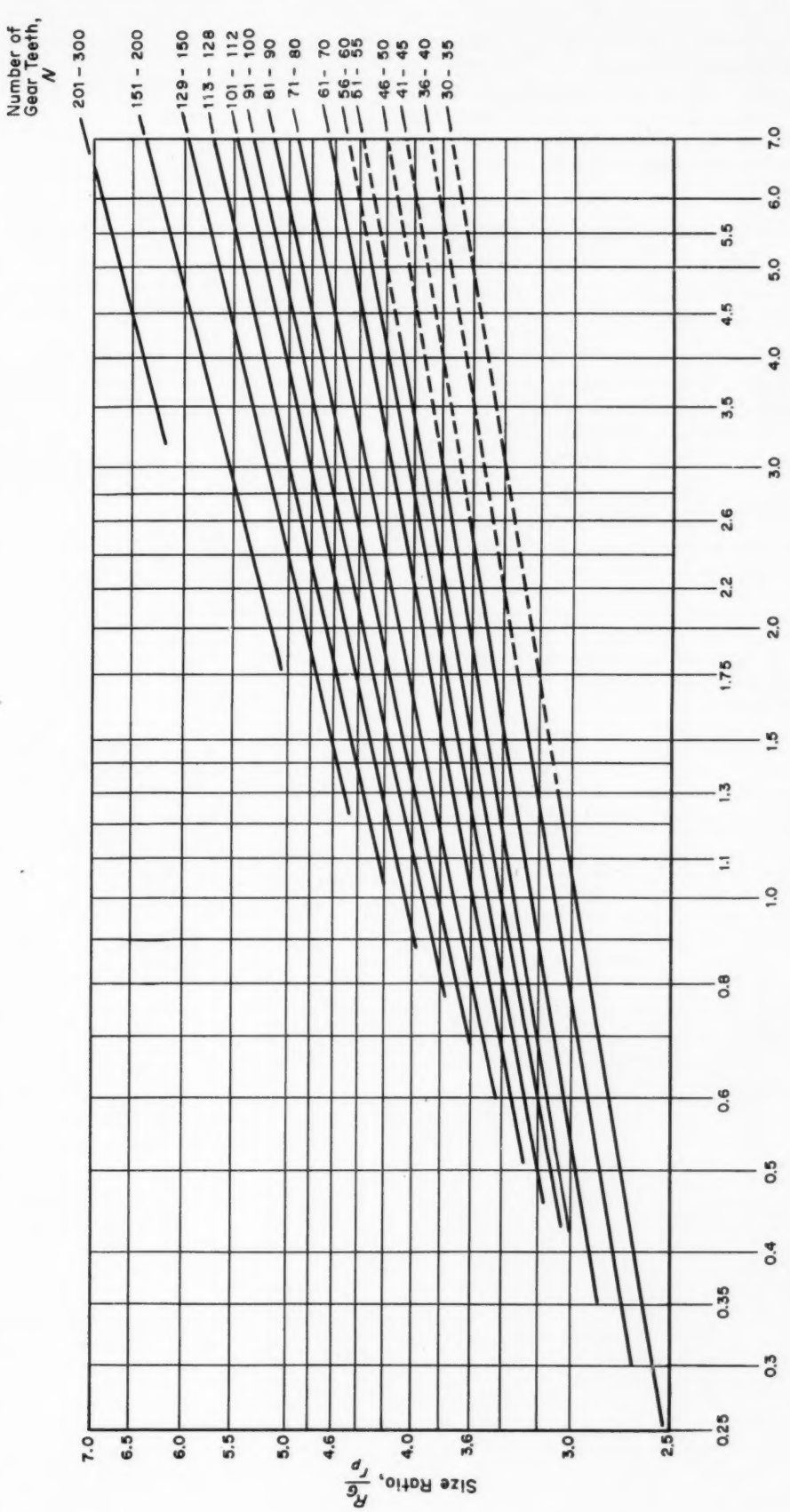


Fig. 11—Gear-ratio chart for finding numbers of teeth on gears in terms of center distance.

cation for standard blank proportions.

Similarly, y_h, which defines the high-point location of the gear tooth along the y axis, makes up part of the gear mounting distance, Fig. 2. From Fig. 12, the x co-ordinate opposite gear-tooth high point is

$$x_h = \sqrt{R_i^2 - (C - z_p)^2} \qquad (20)$$

This value is substituted into

$$r_h = r_i - h_{kr} + x_h \tan \tau \qquad (21)$$

to find a pinion radial dimension r_h. The desired high-point dimension is approximated by

$$y_h = \sqrt{r_h^2 - z_p^2} \text{ (approx)} \qquad (22)$$

Backlash: Customary ways, such as adjustment of hob and pinion tooth thickness, underdepth hobbing, and overdepth hobbing can be used to provide backlash. Another way is simply to advance or withdraw either member of the gear pair along its axis. Running characteristics of a Spiroid gear pair, like a spur gear pair, are not affected by moderate changes either in axial position or in center distance.

The backlash changes, of course, but the "red lead" pattern does not. This property is a consequence of constant lead and pressure angles. It is useful in backlash control, especially in assemblies where little or no backlash can be tolerated. The gears merely are positioned axially to reduce or eliminate the play between the teeth.

EXAMPLE: Blank dimensions and tooth proportions are required for a steel-on-steel Spiroid gear set. Center distance is 2 in.

Fig. 1 and 2 show the final solution. For standard proportions, F, R_i, R_o, x_L, σ, τ, τ_G, and pinion neck diameter, 1.058 in., are found directly from Fig. 12. (Tolerances will be discussed in Part 3 of this series.)

To find lead, Equation 8 and Fig. 11 are used. Fig. 11 indicates that a 31-tooth gear is not feasible with a 2-in. center distance. But, a gear of 62 or 63 teeth and a pinion with 2 threads is within the R_G/r_P range. The gear with 63 teeth is chosen to give a hunting tooth and a 31.5: 1 reduction. Corresponding value of R_G/r_P is 3.93.

From Equation 10,

$$r_P = \frac{2}{0.1041 + 3.93(0.766)} = 0.643 \text{ in.}$$

Thus, $R_G = 0.643\ (3.93) = 2.525$. From Equation 8,

$$L = \frac{2\pi(2.525)(0.766)}{31.5 - 3.93(0.643)(0.994)} = 0.4200 \text{ in.}$$

Pinion outside diameter is found with Equations 11 and 12:

$$r_i = 0.643 - 1.625(0.0875) = 0.501 \text{ in.}$$

$$d_o = 2[0.501 + 2.384(0.0875)] = 1.420 \text{ in.}$$

where x_L is defined by Fig. 12.

Working depth, h_{kr}, Fig. 3, is found from Equation 13. Assuming standard pressure angles $\phi_1 = 10$ deg and $\phi_2 = 30$ deg,

$$h_{kr} = \frac{0.5\left(\frac{0.420}{2}\right)1.004}{\frac{0.1737}{0.966} + \frac{0.500}{0.906}} = 0.144 \text{ in.}$$

This thread dimension is entered in Equation 16 to find mean radius,

$$r_m = 0.501 - \frac{0.144}{2} + 0.827(2)0.0875 = 0.573 \text{ in.}$$

from which the mean spiral angle by Equation 17 is

$$\tan \psi_m = \frac{0.420(1.004)}{2\pi(0.573)} = 0.1170$$

Since $\psi_m = 6$ deg 41 min $<$ 16 deg, a low-side pressure angle of 10 deg is satisfactory.

By Equation 19,

$$\tan \phi_2' = \frac{0.643}{1.625} + \frac{2(0.067)}{0.643[31.5(0.639) - 1.625]} = 0.406$$

This makes $\phi_2' = 22$ deg 6 min. Since $\phi_2 = 30$ deg $>$ 22 deg 6 min + 5 deg, a high-side pressure angle of 30 deg is also satisfactory.

Finally, from Equations 20, 21, and 22,

$$x_h = \sqrt{(2.202)^2 - (2 - 0.067)^2} = 1.056 \text{ in.}$$

$$r_h = 0.501 - 0.144 + 1.056(0.0875) = 0.449 \text{ in.}$$

$$y_h = \sqrt{(0.499)^2 - (0.067)^2} = 0.444 \text{ in.}$$

Fig. 2 shows this dimension as a component of gear mounting distance. Other dimensions determined by the example are also transferred to the drawings, Fig. 1 and 2.

Part 2 of this series will cover efficiencies, and ratings for durability and strength.

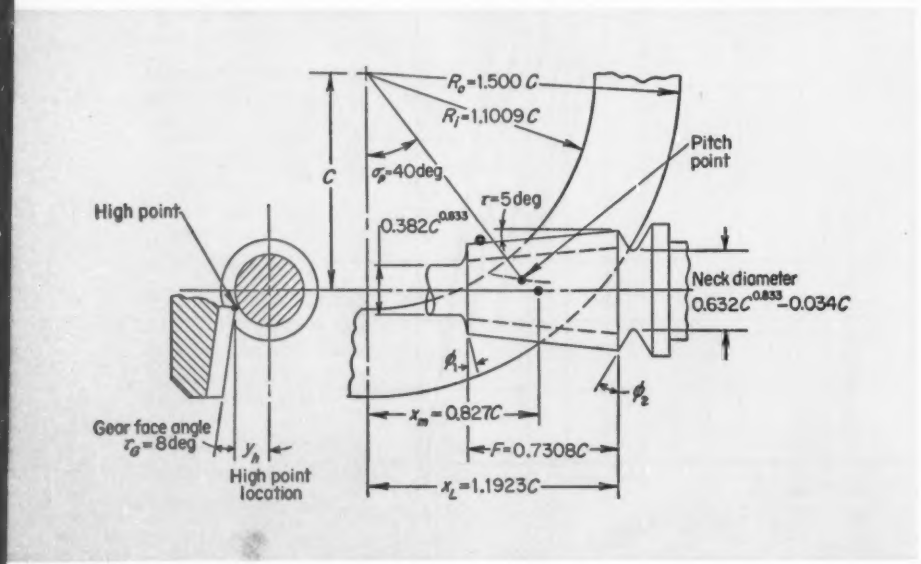
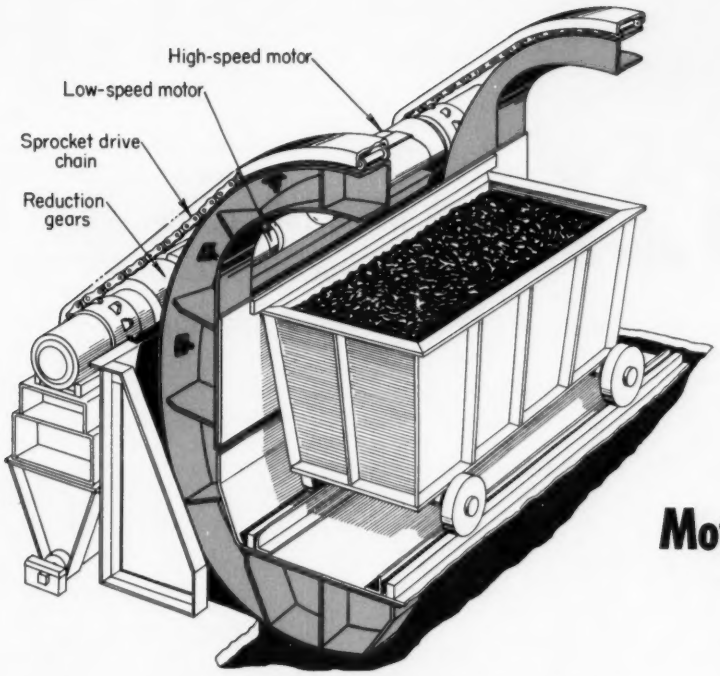
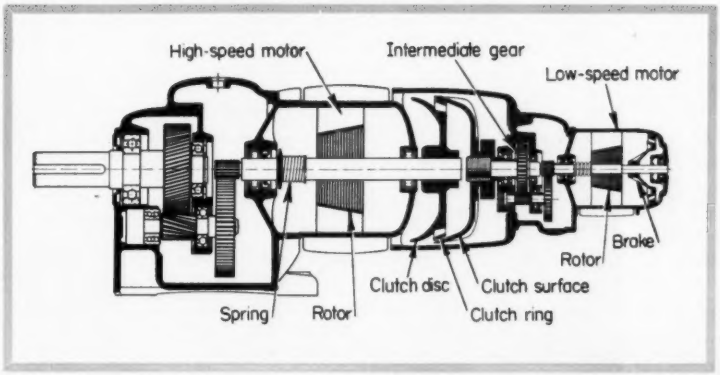


Fig. 12—Standard blank proportions for both members.



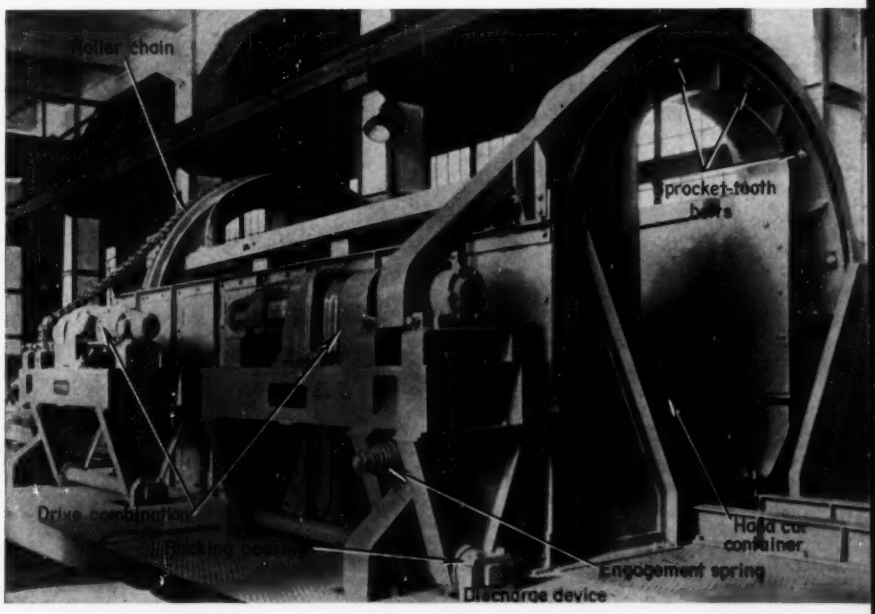
Car Dump Shifts Motors Instead of Gears



CAR DUMP for emptying miners' hand cars clutches two gearmotors together in a co-axial arrangement. Combination of fast and slow-motion drives minimizes shocks and stress without sacrificing running speed. Power operating the running-speed motor also declutches the slow-speed motor. The clutch doubles as a brake when power is off.

ROTOR of the high-speed motor is held axially out of line with its field by the spring that keeps the clutch engaged. Power to the high-speed motor pulls the rotor into line and forces the clutch open, disengaging the low-speed motor. Low-speed gearmotor when energized drives through the high-speed rotor shaft.

SPROCKET TEETH are bolted individually to sprocket hoops for the turnover mechanism. To absorb shocks, motors are mounted on a rocking bearing with an engagement spring to maintain motor load on the chain. Car dump is designed by Demag AG, Duisburg, Germany.



XM 521

Built like a raft, a new floating truck is steadied by foam-filled sponsons

BIG PROBLEM in modern atomic warfare is to maintain dispersion of vehicles during a ground attack. Natural concentration points like bridges, fords, and ferries make attractive targets for the enemy. Obvious answer is vehicles that can pass water obstacles without converging on an optimum crossing.

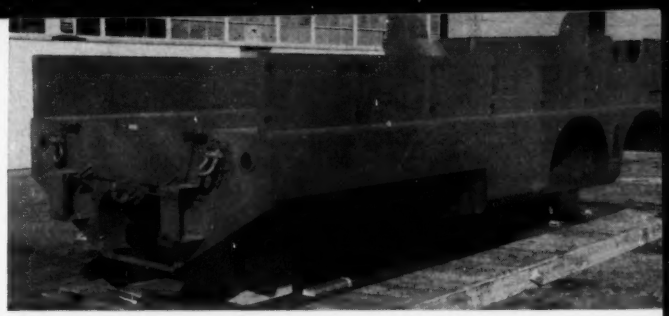
Using aircraft-design techniques, Army engineers developed an aluminum-honeycomb truck body that floats even when its internal watertight compartment is punctured and filled. It can carry a full 5000-lb load across water at 5.2 mph. Vulnerable wheel sponsons are filled with polyurethane foam, with the result that even considerable damage from sunken rocks or enemy fire will not necessarily cause a cripping leak.

In a panic dispersion, the 2½-ton truck can "jump" from a 4-ft bank into water at 25 mph. It can safely enter water from a 60-degree slope at 10 mph. Level land speed is 55 mph. Curb weight is one-third that of a conventional 2½-ton truck—50 per cent less than for an earlier experimental floating truck.

U. S. Army photographs

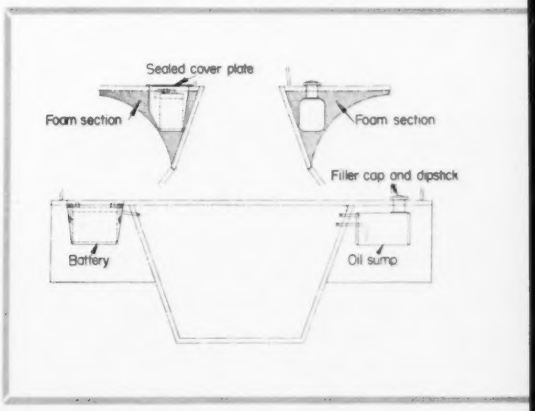
Amphibious 2½-ton truck was designed at Detroit Arsenal and reported at the 1961 International SAE Congress by T. J. Bischoff, S. J. Pearson, and T. R. Gondert.

Body Details

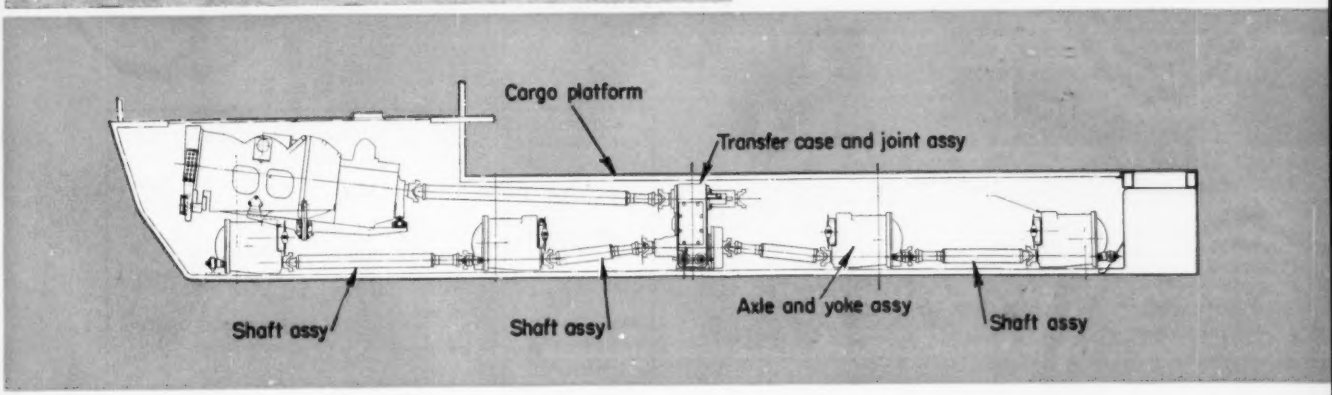


ALUMINUM HONEYCOMB makes the XM521 body sixteen times as strong as one of the same weight made of solid steel—ten times as strong as a body made of solid aluminum. Completely breached, the hull will still float.

DAMAGE from submerged rocks is localized by filling sponsons with polyurethane foam. Foam doubles as a suspending medium for battery, oil sump, and fuel tank, thus eliminating straps and frames.



WET-DECK construction is used. Engine and transmission are sealed inside the hull in a watertight compartment. Crew and payload ride on top an essentially flat raft-like deck. Towing-tank tests showed the bow wave kept the cockpit inundated, so a coaming was added to protect the occupants. A full 5000-lb load of anything with medium or low density tended to make the craft top-heavy; therefore, the bed of the payload compartment was sunk slightly to lower center of gravity of the payload. Cooling air for the engine is admitted forward in the cockpit area and discharged at the side behind the driver's seat.



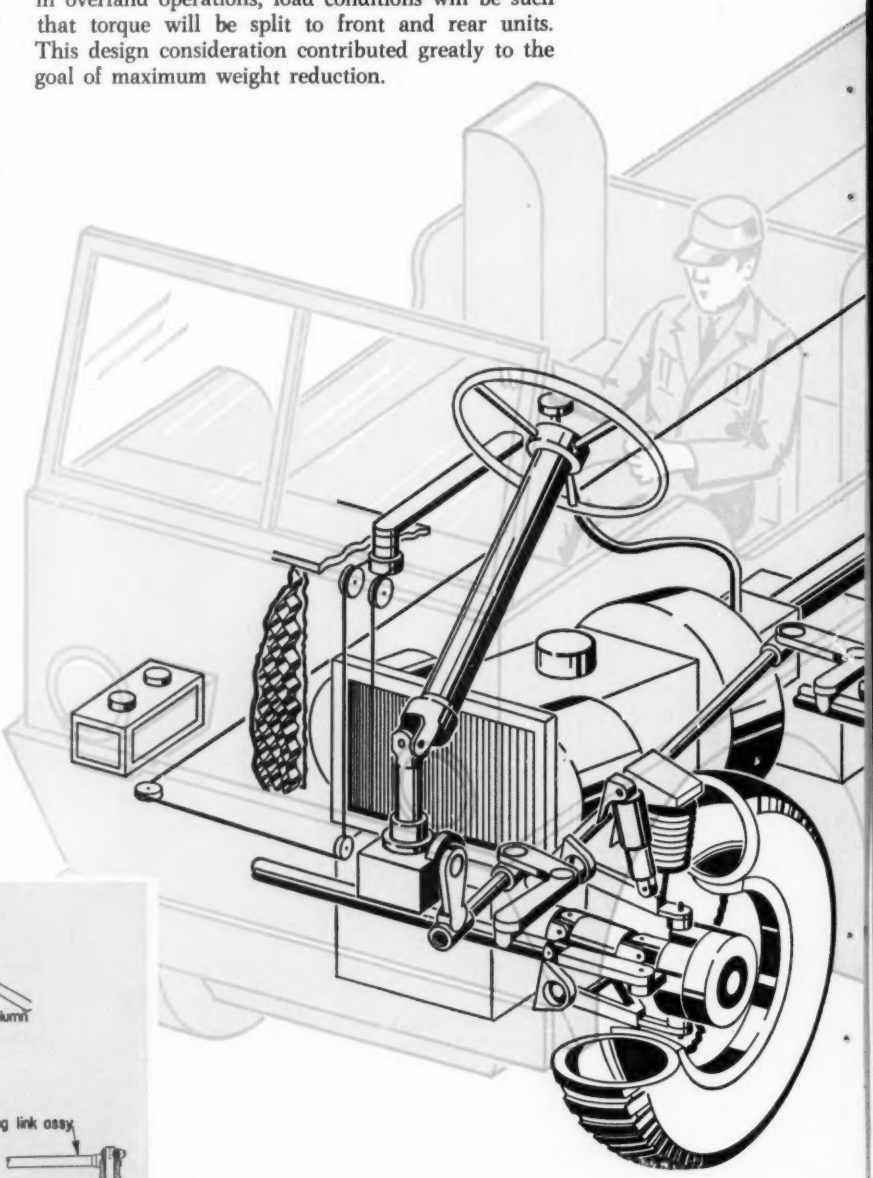
XM 521 *(continued)*

WHETHER OPERATING as a boat or as a truck, the amphibious XM521 is controlled entirely from the driver's seat. Most notable change in control function is switching from steering wheel to the tiller as the vehicle becomes waterborne. In exiting from water, the twin propellers may give useful thrust as front wheels claw for a footing.

Power from the engine is transmitted to wheels and propeller through a transfer case. It offers four options in addition to the four speeds from the transmission:

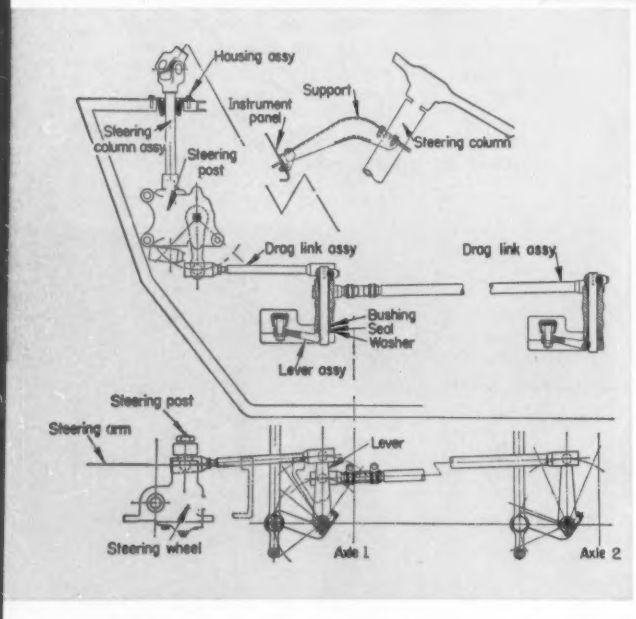
- Neutral
- High-range rear-wheel drive
- High-range all-wheel drive
- Low-range all-wheel drive

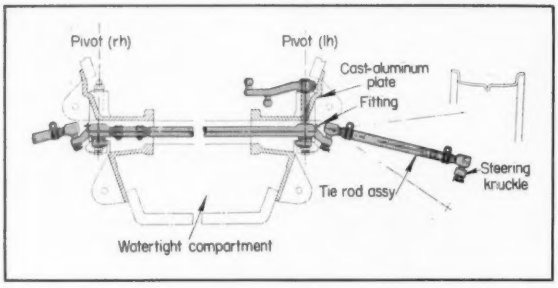
Mechanical interlocks, preventing the use of low-range rear-wheel drive, permit use of lighter-weight rear axles not otherwise capable of carrying maximum engine torque in low gear, low range. It is expected that in overland operations, load conditions will be such that torque will be split to front and rear units. This design consideration contributed greatly to the goal of maximum weight reduction.

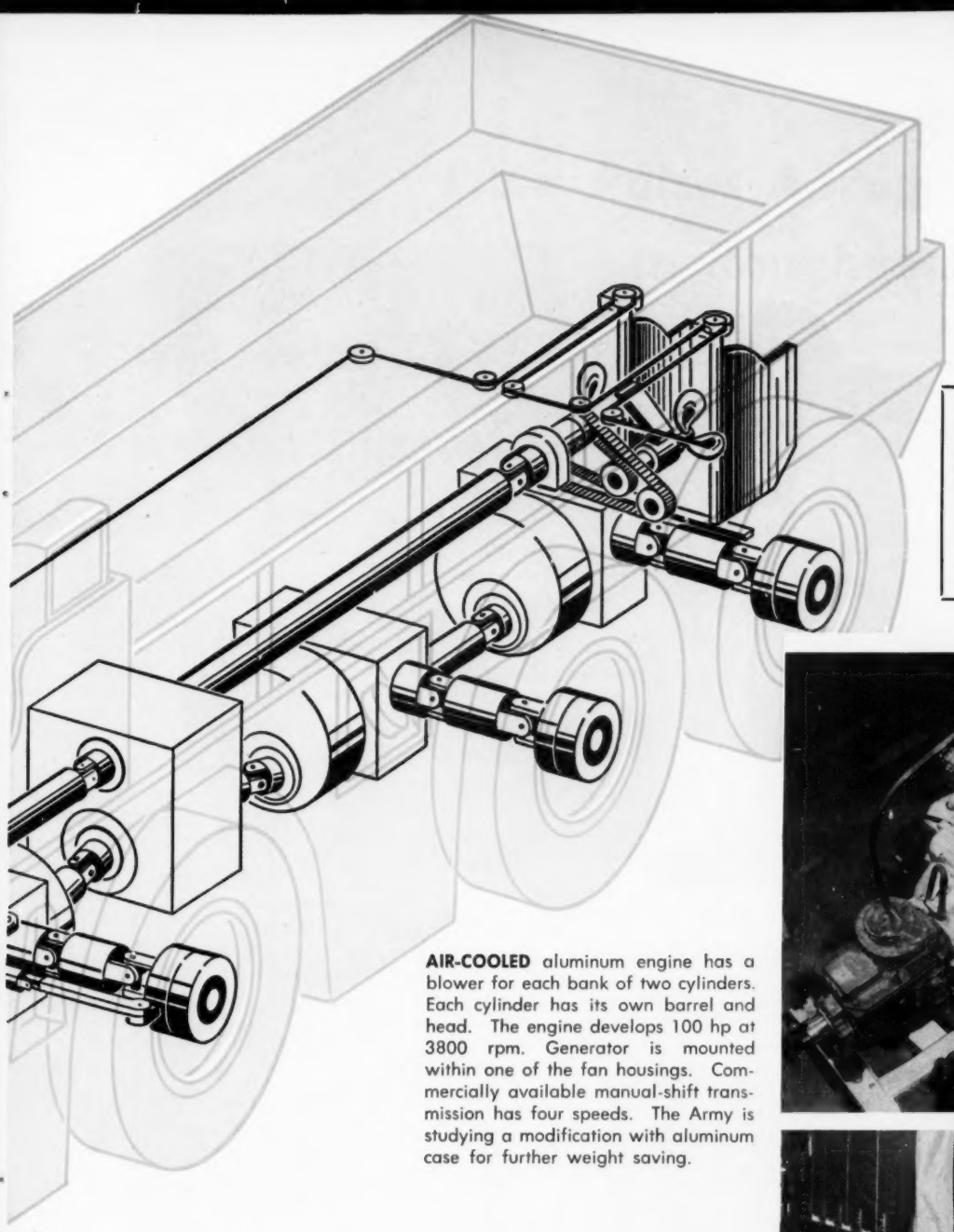


Steering Details

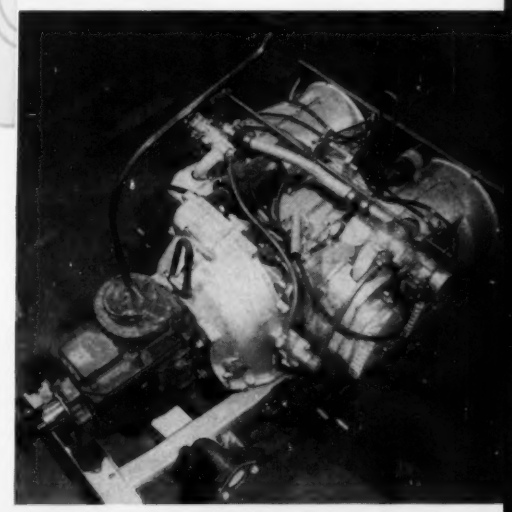
WORM-AND-ROLLER steering gear operate on two front axles through Ackermann-type linkage. Turn angle on rear axle is decreased by linkage between crank arms. Universal joint on steering column changes direction of steering moment.



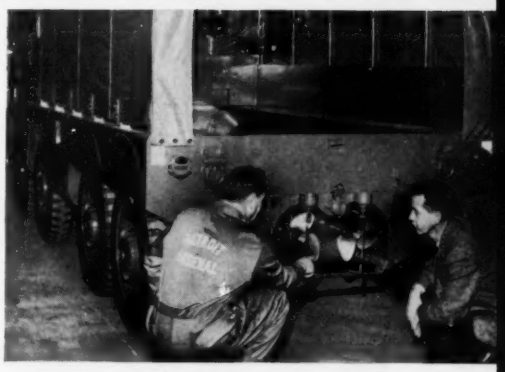




Power-train Details

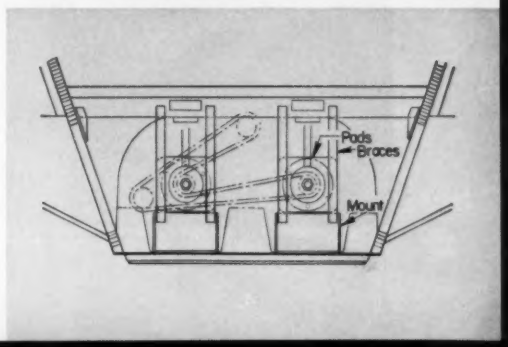


AIR-COOLED aluminum engine has a blower for each bank of two cylinders. Each cylinder has its own barrel and head. The engine develops 100 hp at 3800 rpm. Generator is mounted within one of the fan housings. Commercially available manual-shift transmission has four speeds. The Army is studying a modification with aluminum case for further weight saving.



WHEEL COVERS over rear wheel wells gave added stability by trapping air as the vehicle enters the water. Rudders mounted directly back of twin propellers are operated by a tiller on the dashboard.

TUNNELS through the body pass tie-rod links from one side to the other without communicating with the engine and gear compartment. Cast-aluminum plate caps the tunnel and forms a mounting for the wheel. Steering linkage goes through the rectangular hole. Round hole supports a seal for the power-transmitting axle.

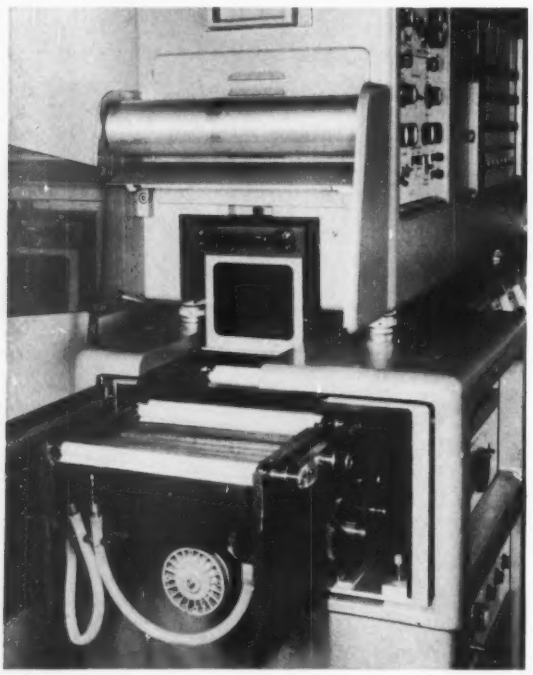


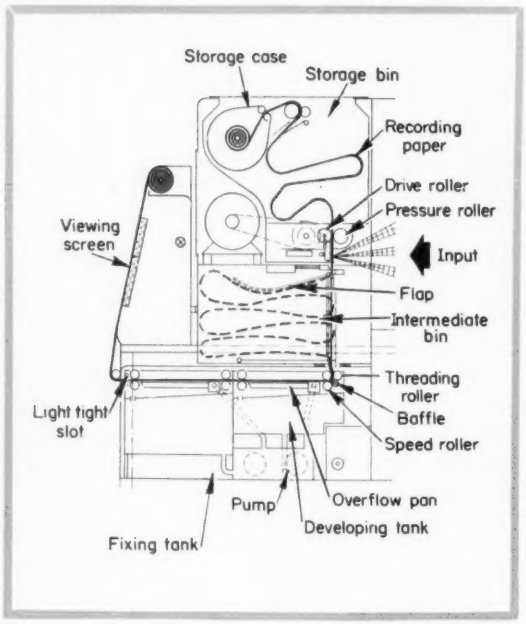
INSIDE-OUT drive belt delivers power from one shaft to the counterrotating propellers. Water speed is 5.2 mph.

One-Sided Developer Gives Instant Oscillograms

ONLY THE EMULSION side of the paper is wetted in a self-contained developer designed into the base of an oscillograph. The paper exits through a slot in the end of the machine dry and ready to read. The design provides a viewing screen for oscillographs best read by rear lighting.

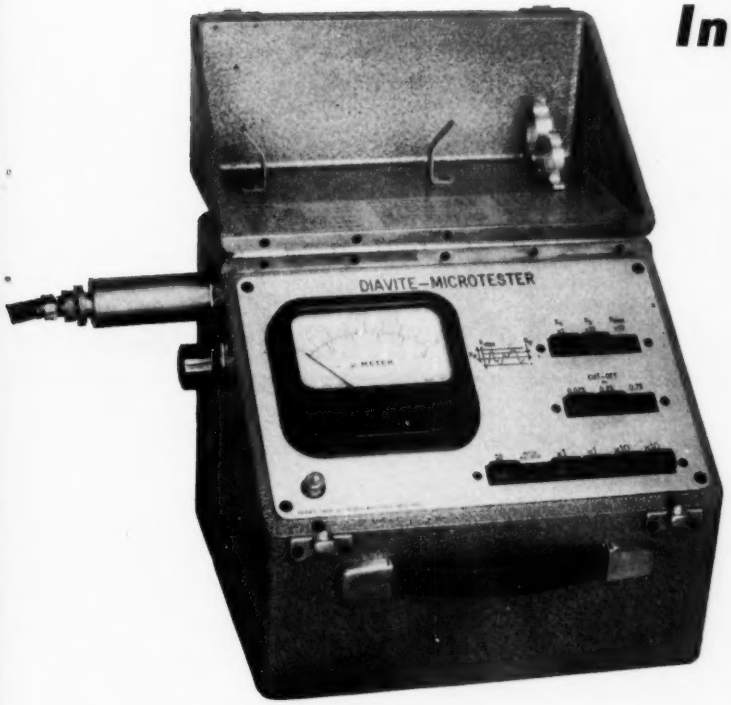
TANKS SLIDE out on rails like a drawer for replenishing, servicing, or threading paper. Corrugations in the bottom support the paper exactly at the solution surface. The oscillograph is a design of Siemens & Halske AG, Munich, Germany.





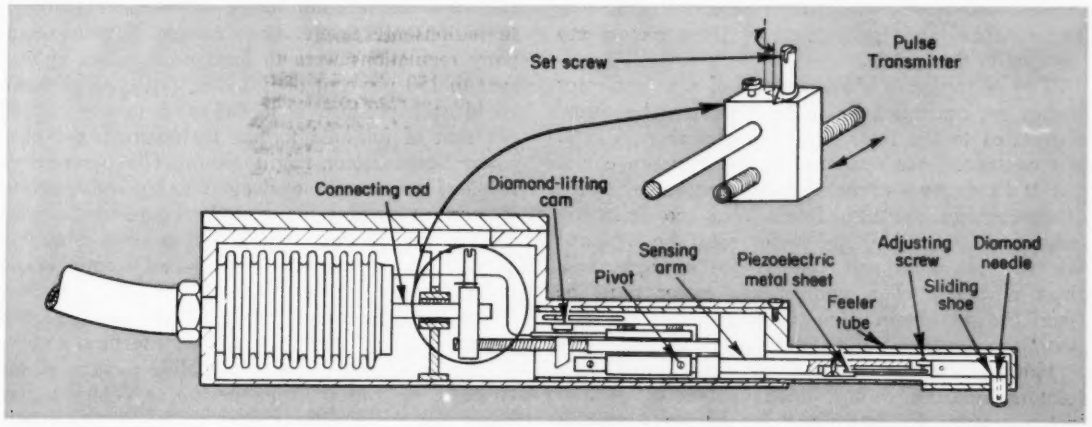
EXPOSURE is faster than processing, so an intermediate bin accumulates the paper in neat folds until it is fed into the processing tanks. Overflow pans maintain a constant level of chemical. The paper moves across the top of the pan, wetting the emulsion side only. Rollers between stages and at the end of the process act as "wringers" to squeeze out excess moisture. Paper passes the light-tight slot practically dry.

Fluid Pulses Advance Probe In Roughness Tester



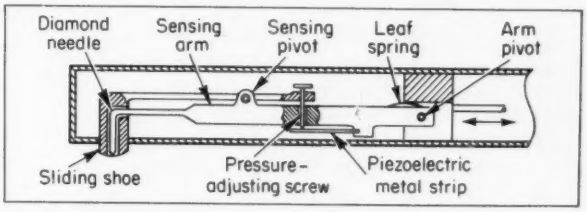
FORWARD MOTION of the probe on a roughness tester proceeds in a succession of minute increments powered by pulses from a closed fluid system. Fluid is held in a rubber tube connecting two bellows assemblies, one in the meter housing, the other in the probe. The head of the transmitting bellows is oscillated by a pushrod and cam that are driven by an electric motor. The fluid transmits this motion to the head of the receiving bellows in the probe housing.

The probe consists of a diamond point in a surrounding shoe which follows gross contours of the part under inspection. Moving relative to the shoe, the point follows surface imperfections and stresses a metal strip to produce a piezoelectric signal. Current from the strip is integrated by the gage equipment and gives a readout in CLA (centerline average) values.



PULSE TRANSMITTER is clamped to the connecting rod by a set screw. Internal escapement gives one-way motion to threaded rod attached to the sensing arm. As the sensing arm moves back, it hits the diamond-lifting cam which rotates it about the pivot to lift the diamond from the test piece. Position of the diamond-lifting cam can be adjusted for a cutoff range of 0.075, 0.25, or 0.75 mm.

RELATIVE CHANGE between shoe and needle is transmitted through the sensing pivot and causes a change in the pressure exerted by the pressure-adjusting screw on the piezoelectric strip. Spring pressure of the strip and a leaf spring ensure that the shoe and needle follow the contour of the test piece. Piezoelectric roughness tester was designed by Swisstool AG, Zurich, Switzerland.



AC MOTOR CONTROL-5

Characteristics and control of

Wound-Rotor Motors

ADJUSTABLE motor performance may be required for certain jobs. Starting current, starting torque, and speed may need to be adjustable. One type of ac drive that permits such adjustments is the wound-rotor motor. Characteristics, control, and applications of these motors are covered in this article.

The performance characteristics of a wound-rotor motor are controlled by adjustable external resistors connected to the rotor circuit by slip rings, Fig. 1. By contrast, rotor resistance of a squirrel-cage motor is fixed. As a result, current, torque, and speed characteristics are also fixed. With no operating adjustments possible, the motor must be designed for best all-round performance. For example, full-load efficiency of a squirrel-cage motor must be sacrificed to obtain high starting torque, or vice versa.

However, further comparison with squirrel-cage motors indicates certain disadvantages of wound-rotor motors: 1. Equivalent breakdown torque is lower because of higher rotor reactance. 2. Inherent construction is less rugged. 3. Greater maintenance is necessary because of slip rings and brushes. 4. Cost is higher, especially in smaller sizes.

Motor Characteristics

Adding resistance to the rotor (secondary) circuit reduces rotor current, and stator (primary) current is reduced proportionally. The effect of added rotor resistance on starting current gains special importance in relation to its simultaneous effect on starting torque. Although starting current decreases with each added increment of resistance, starting torque increases up to point No. 4, Fig. 2, then drops off rapidly.

This characteristic—increasing torque with decreasing current—frequently determines the selection of a wound-rotor motor when starting-current limitations are severe. For example, if power-company regulations were to limit peak values of current to 150 per cent of full-load, this type of motor could still produce a locked-rotor torque of 150 per cent of full-load torque. By contrast, a typical squirrel-cage motor might require 600 per cent of full-load current for equivalent locked-rotor torque. If starting current for a squirrel-cage motor were limited to 150 per cent, a locked-rotor torque of only about 10 per cent of full-load torque would be obtained.

Speed-torque curves in Fig. 3 have been plotted from the seven starting points on the torque curve in Fig. 2 to give a more complete picture of the effect of resistance on motor torque. These curves show that locked-rotor torque can be increased only until it equals breakdown torque at point No. 4. Further increases in resistance reduce starting torque but prevent the motor from reaching maximum or breakdown torque.

The curves in Fig. 3 show that each addition of resistance in the rotor circuit (from points No. 1 through 7) reduces motor speed. Speed reduction is practical only to 50 per cent of synchronous speed. Beyond this point speed becomes unstable because high slip characteristics are produced in a rotor that operates with a high resistance in its circuit. For this reason, speeds corresponding to resistance points No. 6 and 7 would be practical only where constant loads are involved, as on the bridge

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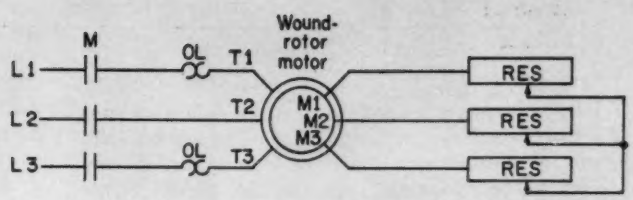


Fig. 1—Basic circuit of wound-rotor motor with adjustable resistors in rotor (secondary) circuit.

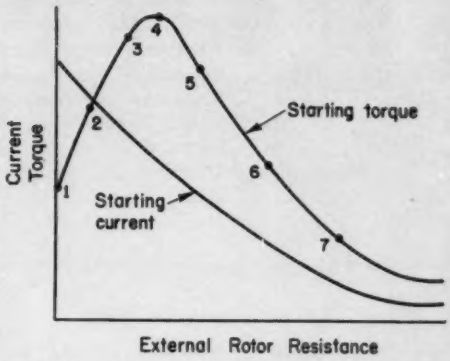


Fig. 2 — Relationship of starting current and torque for various values of resistance in the secondary circuit of a wound-rotor motor.

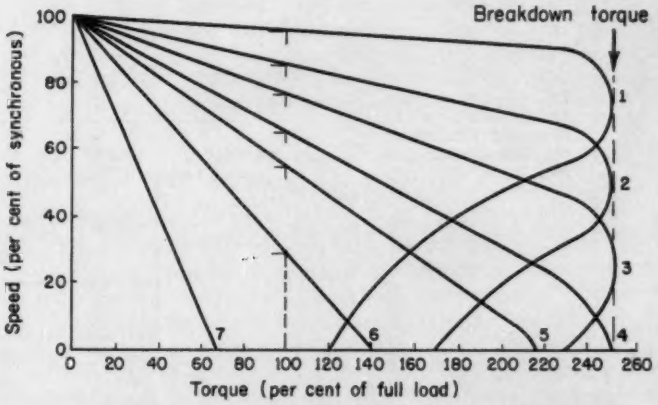


Fig. 3—Speed-torque curves for values of resistance indicated on curve of starting torque in Fig. 2.

or trolley drive of a crane. For example, on the speed curve for point No. 7 a load change from 30 to 40 per cent reduces motor speed from approximately 57 to 42 per cent of synchronous speed.

Normally, a wound-rotor motor is designed to operate with small slip and high efficiency at full load. However, if speed is reduced, slip increases and efficiency decreases.

Motor Control

Since current, torque, and speed of wound-rotor motors can be adjusted, suitable control devices and systems should be selected to take full advantage of these possibilities. Motor controls may be manual, automatic, or a combination of these, and can provide starting, acceleration, speed control, and reversing.

Conventional Controls: The basic control for a wound-rotor motor consists of an across-the-line starter in the stator circuit and a resistor bank in the rotor circuit, Fig. 1. Multipoint control of the resistance may be manual or magnetic. In a manual system a drum controller is generally used with a resistor bank, although a faceplate-type rheostat may be used for small motors.

Where magnetic control is desired, especially for

fully automatic operation in starting, a contactor and an acceleration device must be added for each step of resistance in the rotor circuit, Fig. 4. Any number of resistance steps can be added to the starter, which, of course, can be either a reversing or a nonreversing type.

If control of both speed and acceleration is required, the resistor must be designed for that purpose. Sometimes the resistor has a continuous-duty section for the speed-regulating function. Resistor size and type are determined by:

1. Motor size and rating.
2. Starting current.
3. Duty cycle.

Motor size determines the energy that the resistor must absorb. Resistor design is also based on motor load and on the relationship of speed-torque characteristics of both motor and load. These factors indicate the resistance required to maintain a particular load at a given speed. With the same motor and a given set of rotor resistances, a change in load requirements results in different ranges of operating speeds, Fig. 5.

Starting current, since it must frequently conform to imposed limitations, determines the ohmic value of the resistor. Secondary current, of course, will not necessarily be the same as the limiting value given for primary current. Secondary and primary starting currents, however, are both expressed in per cent of full-load primary current.

Duty cycle refers to the portion of time the resistor is in the circuit during a given time cycle. Service classification of resistors is numerically de-

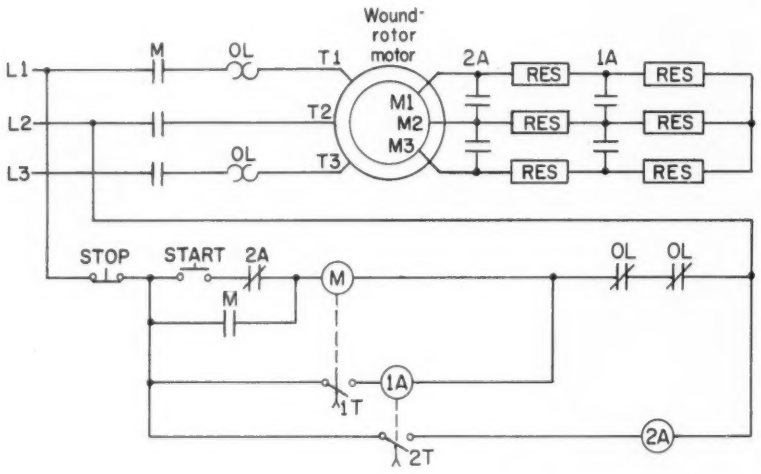


Fig. 4 — Typical magnetic starter with three-step acceleration for wound-rotor motor.

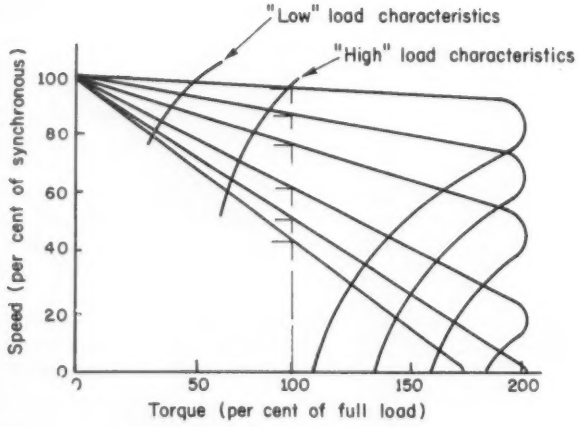


Fig. 5—Speed-torque curves for a wound-rotor motor with the same rotor resistance for two different loads.

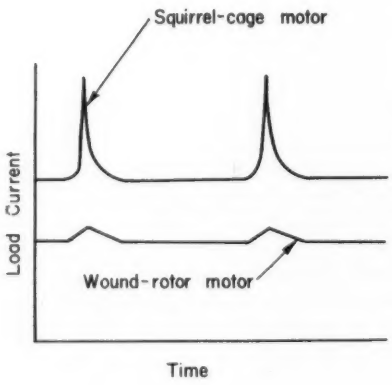


Fig. 6—Typical load-current cycles for a punch-press application.

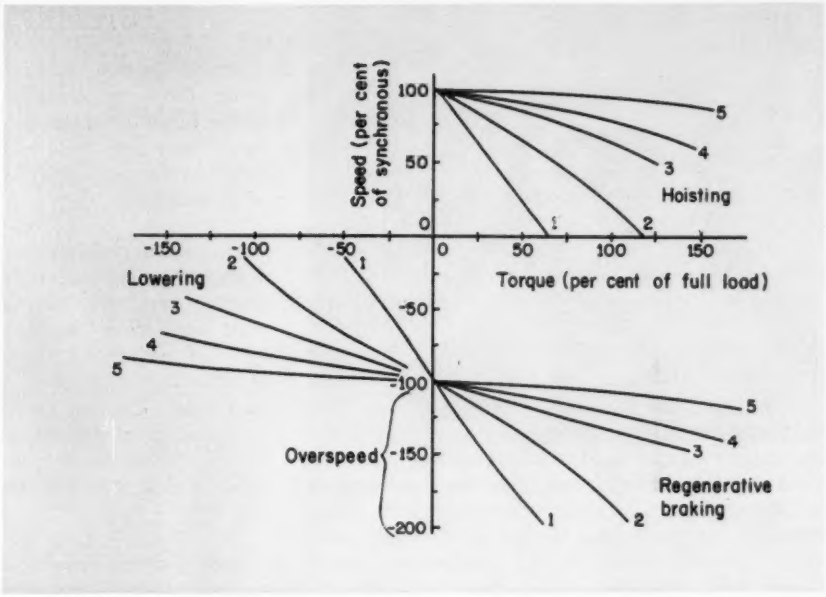


Fig. 7 — Speed-torque characteristics of a wound-rotor motor drive for a typical crane hoist.

Table 1—NEMA Classification for Acceleration Resistors*

Motor Current† (per cent of full-load)	Duty Cycle (sec) 5 on 75 off	10 on 70 off	15 on 75 off	15 on 45 off	15 on 30 off	15 on 15 off	Continuous Duty
	NEMA Classification Number						
25	111	131	141	151	161	171	91
50	112	132	142	152	162	172	92
70	113	133	143	153	163	173	93
100	114	134	144	154	164	174	94
150	115	135	145	155	165	175	95
200+	116	136	146	156	166	176	96

*From NEMA Standards Publication, IC 1-1959, Table 13-1.
†Percentage values shown are approximate values on first point when motor is started from rest.

fined according to starting current and duty cycle, Table 1.

Static Controls: Where highly repetitive cycles are required or where stepless control is necessary, static devices are commonly used to replace conventional contactor and relay systems in wound-rotor motor control. A static controller incorporates either fixed or saturable reactors in the rotor circuit. These reactors take the place of the accelerating contactors in a conventional controller.

A static controller, when used for starting a wound-rotor motor, provides smooth acceleration with practically constant torque up to running speed. The motor then returns to its required running torque while maintaining a nearly constant speed.

For different operating speeds, a controlled saturable reactor is placed in the rotor circuit with the accelerating resistor. Control of the saturable reactor can be as simple or as refined as the application demands. If definite operating points are required, a simple control resistor can be used to vary reactor saturation. If an infinite number of points with load regulation are required, a magnetic amplifier with several control windings can be used.

Static controllers also can be used to reverse motor rotation. Here, saturable reactors in the primary circuit take the place of the reversing contactors in conventional controllers. The motor is reversed by controlling saturation of the reactors.

Applications

Wound-rotor motors can be applied on either constant-speed or adjustable-speed drives. They are particularly suitable for smooth acceleration of loads in applications which require high starting torque with low starting current. Typical applications include elevators, ventilating fans, printing presses, pumps, compressors, conveyors, pulverizers, stokers, and positive-pressure blowers.

The flywheel load of a punch press is another typical application. A squirrel-cage motor would draw a pulse of load current proportional to the load peak which occurs during each cycle of press operation. A wound-rotor motor, however, with resistance in its secondary circuit, slips or slows down during the draw operation of the press and reaccelerates the flywheel during the balance of the cycle. This acceptable loss in speed has the effect of smoothing load current, Fig. 6.

One of the most important fields of wound-rotor motor application is that of crane hoists. An estimated 75 per cent of all crane-hoist systems are powered by alternating current. Normally, no unusual problems are present in the hoisting cycle of crane control; however, in lowering, the motor tends to overspeed because both motor and load exert a downward force.

Torque curves for hoisting and lowering of a crane hoist are shown in Fig. 7. The relationships in the hoisting cycle are typical of wound-rotor

motors. For the lowering cycle, the effects of regenerative braking require special attention.

Lowering-speed No. 1, with maximum resistance in the rotor circuit, minimizes the regenerative torque. With the additional weight of the load, this minimum retarding force may permit the motor to overspeed to approximately 200 per cent of synchronous speed.

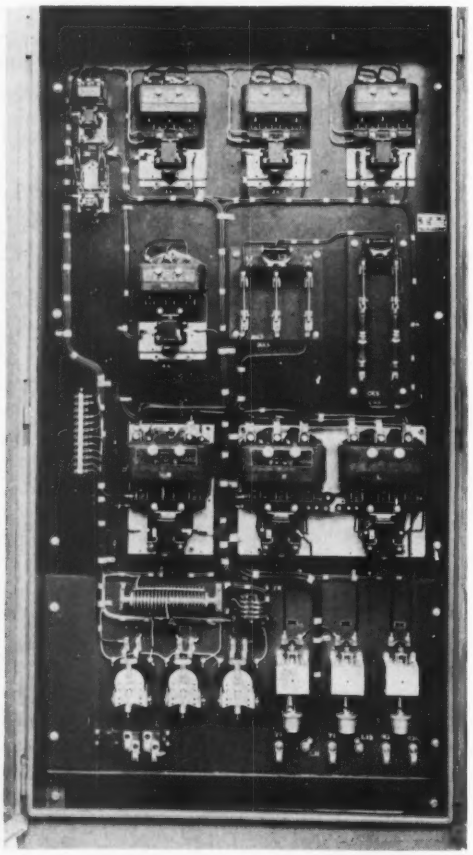
As resistance in the rotor circuit is reduced, lowering speed is checked further by regenerative braking until resistance is at a minimum (at lowering-speed No. 5). At this point, the lowering speed is just above 100 per cent of synchronous speed. These effects of resistance on lowering speed apply only where lowering speed exceeds synchronous speed. Unless additional control equipment is used, no further speed reduction is possible.

Braking Methods

Several techniques are used with wound-rotor motor drives in crane and hoist applications to obtain below-synchronous speeds in lowering. Slow-down may be accomplished by plugging; final stopping and holding must be achieved with a magnetic brake.

Mechanical braking: Generally, a mechanical load brake acts directly on the motor shaft to oppose rotation during the lowering cycle. Thus, the motor must drive the load down against the retarding force of the brake. Because of the relatively inconsistent friction of a mechanical brake, speed control in lowering lacks stability. This type of control is used mainly for medium-duty hoists. A crane-hoist control for use with a mechanical load brake and a magnetic holding brake is shown in Fig. 8.

Eddy-Current Braking: Mechanically connected to the motor shaft, an eddy-current (electrical) load brake provides retarding torque during lowering



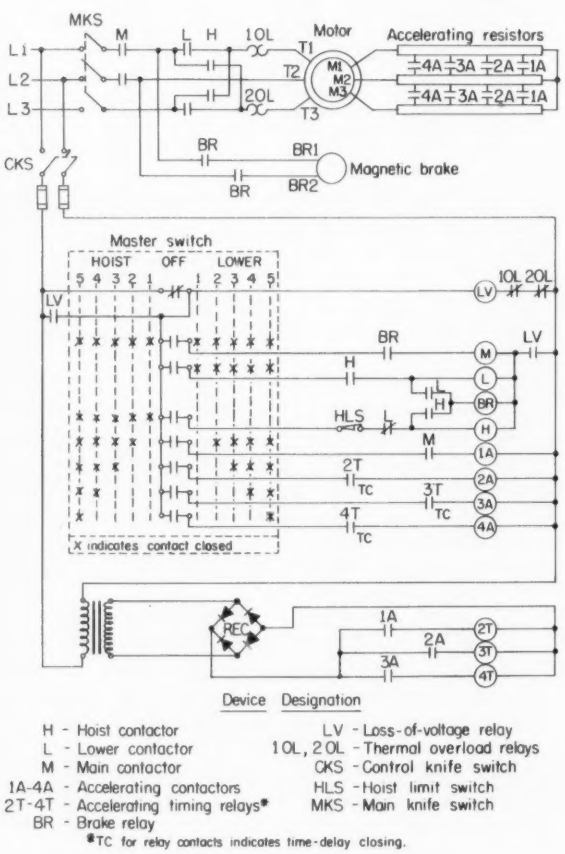


Fig. 8—Typical controller and schematic diagram for crane-hoist applications which use a mechanical load brake (not shown). Connections for magnetic holding brake are indicated on the diagram.

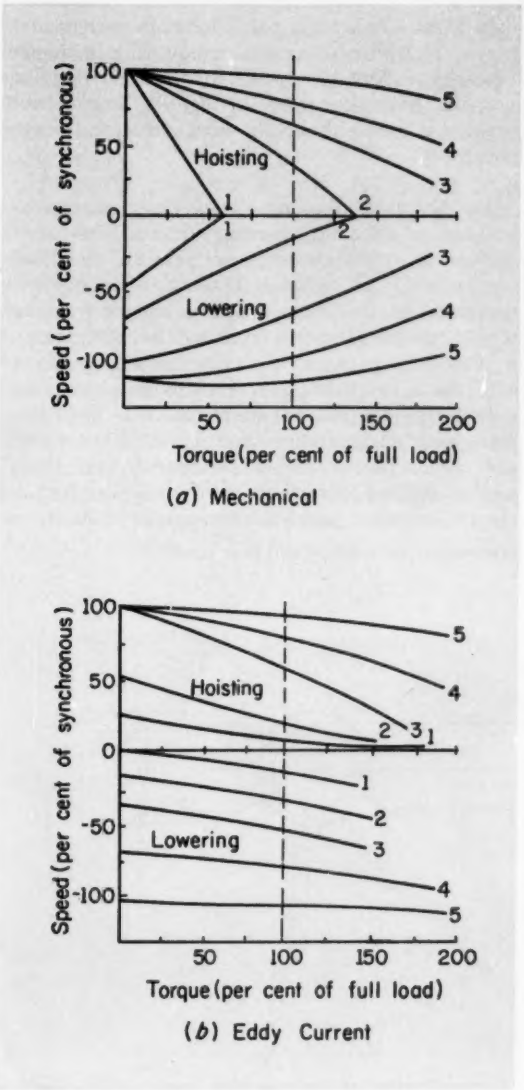


Fig. 9—Speed-torque curves of a wound-rotor motor with, *a*, mechanical, and *b*, eddy-current (electrical) load braking for a crane-hoist application.

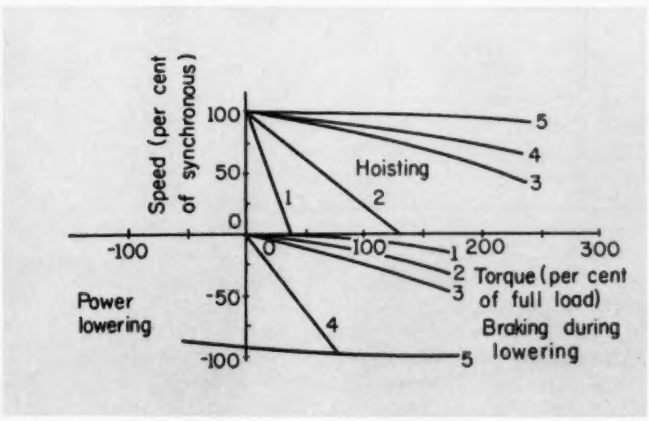


Fig. 10—Speed-torque characteristics of typical crane-hoist wound-rotor motor with dc dynamic braking.

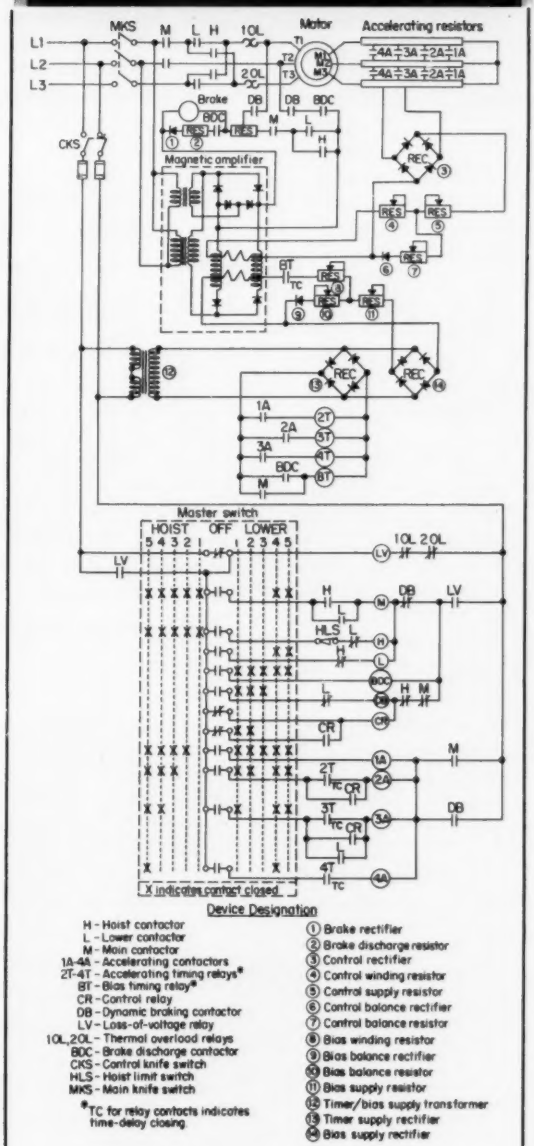


Fig. 11—Typical controller and schematic diagram for a crane-hoist using compensated dc dynamic lowering.

and usually for one or two control points during hoisting. Relative motion between the brake windings produces eddy currents which set up forces to resist rotation. When the motor is not running, no resisting force is created. Again, a magnetic brake must be used for holding.

The eddy-current load brake provides better braking control than a mechanical load brake, particularly during lowering. However, where a long lift cycle or otherwise severe duty is involved, the power required for load braking, if used during hoisting, may affect motor size.

Mechanical and electrical load braking characteristics may be compared in Fig. 9. With mechanical load braking, Fig. 9*a*, the control points for lowering are far apart and speeds are slow except for light loads. The control points for eddy-current braking in Fig. 9*b* permit uniform lowering, and point No. 1 gives very low speeds for precision handling. For the hoisting curves in Fig. 9*b*, eddy-current braking is used only on the first and second control points.

Dc Dynamic Braking: Two types of dynamic braking or dynamic lowering—dc and ac—can be applied to wound-rotor motors. During the lowering cycle for dc dynamic braking, a dc supply is connected to the stator winding after the ac supply is cut off. The power circuit for the stator of a wound-rotor motor is similar to the power circuit for dynamic braking of a squirrel-cage motor.[2]

Lowering for control point No. 1 in Fig. 10 is done with all resistance shorted out of the secondary circuit, except for a permanent (stabilizing) section. Adding increments of resistance to the rotor circuit increases the lowering speed of each suc-

[2]References are tabulated at end of article.

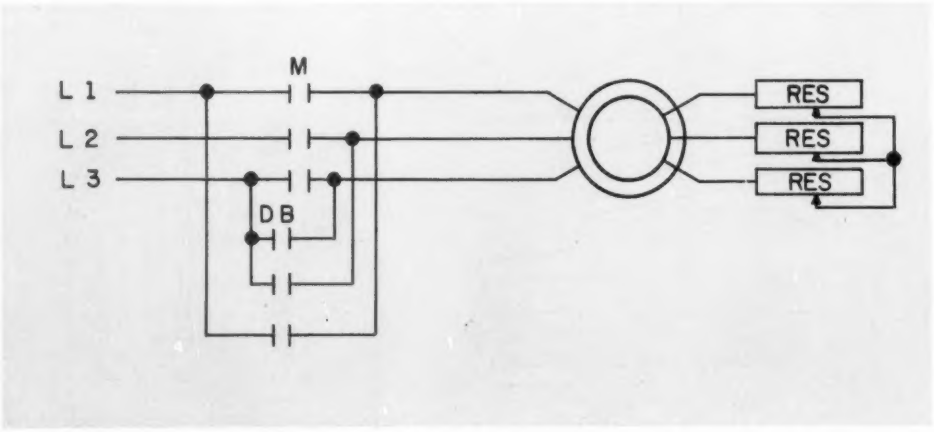


Fig. 12—Power circuit for ac dynamic braking of a wound-rotor motor.

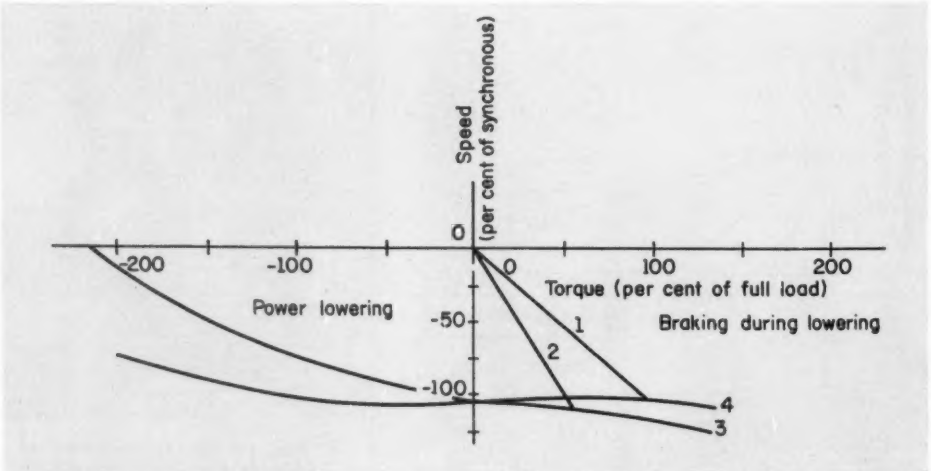


Fig. 13—Speed-torque lowering characteristics of a wound-rotor motor with ac dynamic braking for a typical crane-hoist application.

cessive control point (No. 1 through No. 4). Adding more resistance than is used for point No. 4 offers no practical advantage because increasingly poor control results. Therefore, for faster lowering speeds, dc dynamic braking is removed for control point No. 5.

Under the conditions of point No. 5, the stator is disconnected from the dc supply and is reconnected to the ac supply. Simultaneously, most resistance is removed from the rotor circuit, and the motor overspeeds. As shown in Fig. 7, low rotor resistance results in high regenerative braking which prevents the motor from operating much beyond synchronous speed.

Dc dynamic braking acts similarly to eddy-current braking in retarding the load during all lowering speeds except the fastest one. A major difference, however, is that dc dynamic braking plays no part in hoisting. A magnetic brake must be used for holding purposes. Dc dynamic braking for crane control is suitable for precision hook work in shipyards, foundries, assembly lines, and other applications where creeping speeds are required.

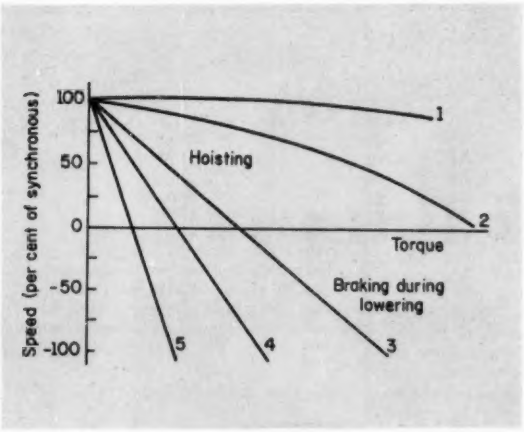


Fig. 14—Speed-torque characteristics of typical crane-hoist wound-rotor motor with counter-torque control.

Probably the most common method for obtaining power is to use a motor-generator set to supply a constant source of dc for dynamic braking. However, improved characteristics are obtained with a type of crane-hoist control called compensated dc dynamic lowering, Fig. 11. This type of control uses a rectifier and magnetic amplifier, rather than a motor-generator set, to provide the dc supply. Controlled by feedback signals from the rotor circuit, the rectifier/magnetic-amplifier circuit compensates for load changes, and supplies appropriate values of dc to the stator windings for controlled lowering.

Regardless of the amount of motor load, heavy currents are present in a conventional dc dynamic-braking circuit. As a result, the drive motor may overheat. Compensated dc dynamic braking provides sufficient power for safe lowering, yet eliminates overheating problems because less average current is required.

Curves of operating speeds for automatic adjustment of dc supply are extremely flat, indicating desirable performance even at the lowest speeds. Also, torques available for decelerating a load far exceed minimum safe values. Thus, compensated dc dynamic lowering is an inherently safe system which avoids the danger of instability or run-away motors.

Ac Dynamic Braking: Retarding torque for ac dynamic braking is produced by connecting the stator of a wound-rotor motor to single-phase ac. As with dc dynamic braking, increasing the resistance in the rotor circuit increases the lowering speed, Fig. 12. For high lowering speeds, dynamic braking is removed and the motor is reconnected to three-phase ac. This permits the motor to drive the load down at speeds somewhat in excess of synchronous speed. Regenerative braking furnishes the retarding torque above synchronous speed.

Typical speed-torque performance curves for the lowering cycle are shown in Fig. 13. Hoisting is unaffected by ac dynamic braking, and hoisting curves are similar to those shown in Fig. 7, 9*a*, and 10. Because over-all control is poor, ac dynamic braking is not well suited to low-speed or precision operations. Also, heat losses in the motor can double during the lowering cycle. The main advantages of ac dynamic braking are simplicity and ruggedness. As with preceding braking methods, stopping and holding must be accomplished by a magnetic brake.

Counter-Torque Braking: During hoisting, a motor provided with counter-torque braking operates in the conventional manner. For lowering, however, instead of reconnecting the motor to reverse its direction of rotation, rotor resistance is increased, reducing motor torque so that the motor cannot raise or even hold the load. The available torque merely serves to retard downward travel. Lowering speed is controlled by varying the rotor resistance.

Counter-torque braking provides rather poor control during lowering. In the performance curves of Fig. 14, counter torque is not used in the last lowering speed (point No. 5). Instead, the motor drives the load down somewhat beyond synchronous speed, but further increase in speed is retarded by regenerative braking. Generally, counter-torque braking is most applicable for operations where the load does not vary greatly—for example, magnet and bucket drives.

Final article in this series will discuss the characteristics and control of synchronous motors.

References

This article is the fifth in a series by J. Ronald Wickey and Arthur S. Newman Jr. on ac motor control. Previous articles and issues of Machine Design in which they appeared are:

1. Squirrel-Cage Motors ..... December 22, 1960
2. Across-the-Line Starting ..... January 5, 1961
3. Reduced-Voltage Starting ..... January 19, 1961
4. Starting Multispeed Motors ..... February 2, 1961

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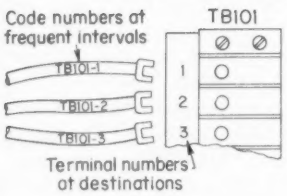
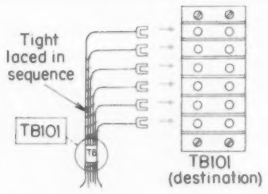
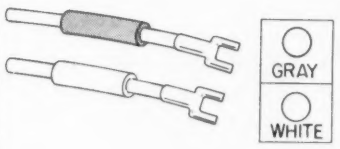


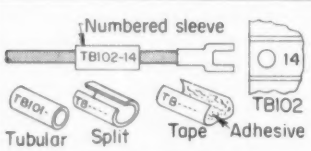
MATCHING NUMBERS marked on wires and wire destinations. This method requires a special machine to mark numbers on wire. It also requires advance planning because wires cannot be marked after assembly.



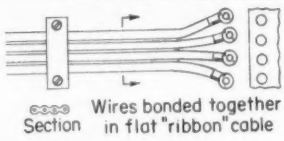
TIGHT LACED CABLE with predetermined termination breakouts. The main trunk of the cable must be clamped in place to prevent its twisting one-half turn. Where more than one such cable exists in the same area, the main destination of each cable should be marked.



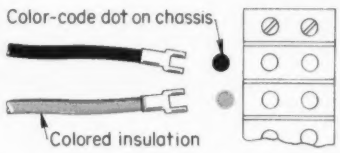
COLOR-CODED SLEEVES and code names printed or molded in destinations. Parts are inexpensive, readily available, and easy to install. No special tooling is required.



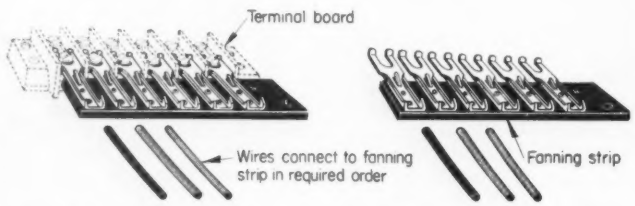
NUMBERED SLEEVES and corresponding numbers on terminals. Sleeves are available in various forms, shown. Tubular sleeves must be placed on wires before terminal lug is attached to free end of wires. Split sleeves and tape-type sleeves can be placed on wires after cable has been assembled.



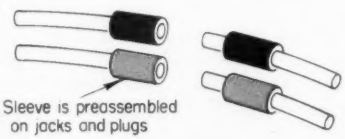
RIBBON CABLE with all wires bonded together in a flat ribbon. Often, ribbon cable can be used without any marking code because the wires are always arranged in the same order, and the connecting sequence is obvious. Also available in colors.



COLOR-CODED WIRE and corresponding colored dots at destinations. Colors should be limited to ten most commonly available: Black, brown, red, orange, yellow, green, blue, violet, gray, and white. Intermediate shades are too difficult to distinguish.



FANNING STRIP with wires permanently assembled. Strip is removed as a unit when a disconnect is required. Correct wiring is assured and maintenance time is saved.



COLOR-CODED PLUGS AND JACKS with insulated sleeve permanently assembled at time of manufacture. This type coding is used extensively for in-line connections.

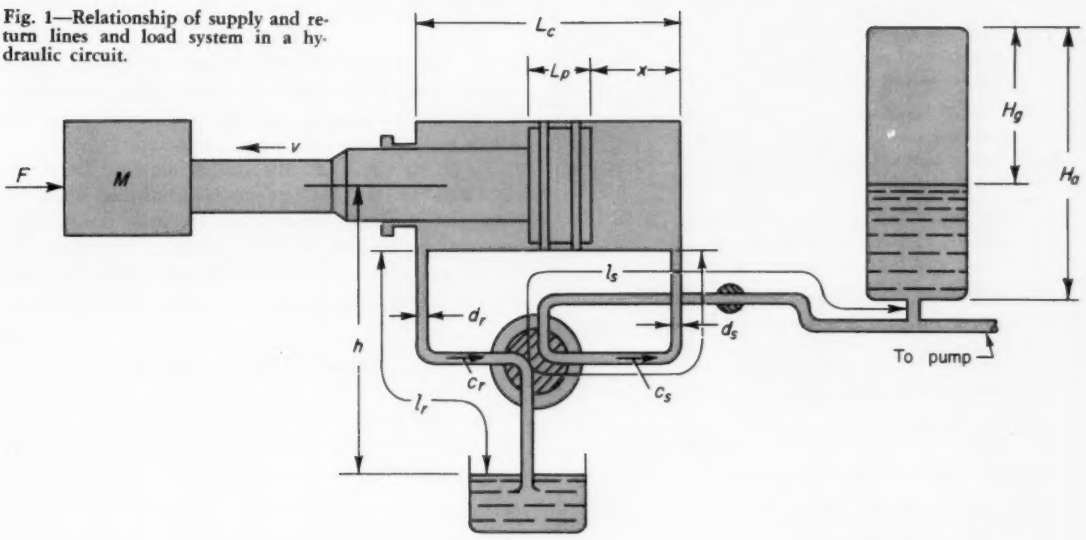


Fig. 1—Relationship of supply and return lines and load system in a hydraulic circuit.

How to Predict

Dynamic Performance of Hydraulic Cylinders

- *Step-by-Step Procedure*
- *Detailed Analysis*

BRUNO SACHS
Vice President
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Union, N. J.

EXPECTED performance of a hydraulic cylinder system can be only approximated by traditional methods based solely upon fluid flow and cylinder displacement. Accurate prediction requires consideration of such factors as physical configuration, mechanical friction, flow losses, inertia forces, and opening period of the operating valve.

This article presents a rational method for evaluation of hydraulic velocities and pressures in the system, piston velocity as a function of piston displacement, and piston displacement as a function of time.

In such a drive, Fig. 1, three coupled subsystems act simultaneously:

1. Drive system composed of the pressure fluid in the accumulator, in the supply line, and in the drive cylinder side; and the piston and piston rod.

Nomenclature

A_a = Area of accumulator, sq ft
A_r = Area of piston rod, sq ft
A_s = Area of head end of piston, sq ft
a_r = Area of return line from piston, sq ft
a_s = Area of pressure supply line to piston, sq ft
C_1 = System constant, defined in Equation 5
C_2 = System constant, defined in Equation 10
c = Velocity of fluid in section l of line, fps
c_a = Velocity of fluid at accumulator outlet, fps
c_r = Velocity of fluid in return line, fps
c_s = Velocity of fluid in supply line, fps
c_v = Velocity of fluid at control valve entrance, fps
c_{v1} = Velocity of fluid at control valve entrance, at time $2\,l_s/u$, fps
d_r = Diameter of return line, ft
d_s = Diameter of supply line, ft
E_f = Modulus of elasticity of the fluid, psf
E_l = Modulus of elasticity of line material, psf
e = Base of natural logarithm, 2.718
F = Force of load, lb
G = Weight of piston and rod, lb
g = Acceleration of gravity, 32.16 ft per sec^2
H_a = Height of accumulator, ft
H_g = Height of gas in accumulator, at time $t = 0$, ft
h = Height of piston axis above sump, ft
L_c = Length of cylinder, ft
L_p = Length of piston, ft
l = Length of a section of line, ft
l_r = Length of return line, cylinder to reservoir, ft
l_s = Length of supply line, accumulator to cylinder, ft
M = Mass of load, lb
p = Pressure of fluid in section l of line, psf
p_a = Pressure in accumulator, psf
p_r = Pressure on rod end of piston, psf
p_{r1} = Pressure on rod end of piston, at time t_1, psf
p_{r2} = Pressure on rod end of piston, at time t_2, psf
p_s = Pressure on head end of piston, psf
p_{s1} = Pressure on head end of piston, at time t_1, psf
p_{s2} = Pressure on head end of piston, at time t_2, psf
p_v = Pressure at control valve entrance, psf
R_k = Frictional resistance of piston in cylinder, lb
R_s = Frictional resistance of stuffing box, lb
s = Wall thickness of line, ft
t = Time, sec
t_1 = Time at which the control valve is completely open, sec
t_2 = Time at which the piston stroke is completed, sec
u = Velocity of sound, fps
v = Piston velocity, fps
v_{st} = Piston steady-state velocity, fps
v_1 = Piston velocity at time t_1, fps
v_2 = Piston velocity at time t_2, fps
x = Piston displacement, ft
x_1 = Piston displacement, at time t_1, ft
x_2 = Piston displacement, at time t_2, ft
Z = Piston valve resistance coefficient, fully opened
Z_r = Sum of the resistance coefficients of all the resistances in the return system, referred to velocity c_r
Z_s = Sum of the resistance coefficients of all the resistances in the supply system, referred to velocity c_s
ρ = Density of drive fluid, lb per cu ft

2. Return system consisting of the pressure fluid in the return cylinder side and in the return line.
3. Load system, represented in Fig. 1 by mass M and force F.

In the evaluation of system performance, the system may be assumed to be completely nonelastic. However, for greater precision the elasticity of the fluid and the line must be considered.

In either situation, the piston, starting from rest, operates in a transient-state condition, and approaches a steady-state condition with time. However, a preliminary analysis under steady-state condition shows the influence of design parameters upon piston velocity.

Steady-State Condition

In Fig. 1, consider the piston to be in motion. Steady-state piston velocity $v = dx/dt = v_{st}$. The summation of forces acting on the piston is:

$$A_s p_s - (A_s - A_r) p_r - R_k - R_s - F = 0 \qquad (1)$$

Pressure p_s and back pressure p_r can be expressed in terms of v_{st} by combining the Bernoulli equation for steady state and the continuity equation:

$$p_s = p_a - \frac{\rho v_{st}^2}{2g}\left[1 + Z_r\left(\frac{A_s}{a_s}\right)^2 - \left(\frac{A_s}{A_a}\right)^2\right] \qquad (2)$$

and

$$p_r = \frac{\rho v_{st}^2}{2g}\left[\left(\frac{A_s - A_r}{a_r}\right)^2 (1 + Z_r) - 1\right] - \rho h \qquad (3)$$

Equations 2 and 3 can be substituted into Equation 1, and the result simplified and rearranged to

$$v_{st} = \sqrt{\frac{0.97\,A_s p_a - F}{C_1}} \qquad (4)$$

where

$$C_1 = \frac{\rho}{2g a_s^2}\left[(1.03\,A_s - 0.88\,A_r)(A_s - A_r)^2(1 + Z_r) + 0.97\,A_s^3 Z_s\right] \qquad (5)$$

Quantity C_1 contains geometrical and physical quantities pertinent to the entire drive system. This characteristic of the drive shows the influence on piston velocity of such design parameters as size of piston, piston rod, and line, as well as resistances in the lines.

Transient Condition, Nonelastic System

To follow the cylinder operation with as few simplifications as possible, consider the actual piston movement in at least two steps, or periods. The piston starts from rest. Movement is started by operation of the control valve. During the first, or opening, period the valve resistance varies from infinity at time $t = 0$ and position $x = 0$, to Z when fully opened at $x = x_1$ and $t = t_1$. At this

point, the piston velocity is designated as v_1.

The second period is from $x=x_1$, $t=t_1$, $v=v_1$, $p_s=p_{s1}$, and $p_r=p_{r1}$ to $x=x_2$, $t=t_2$, $v=v_2$, $p_s=p_{s2}$, and $p_r=p_{r2}$.

For both periods, the force equation is:

$$A_s p_s - (A_s - A_r)p_r - R_k - R_s - F = \left(\frac{G+M}{g}\right)\frac{dv}{dt} \qquad (6)$$

Piston pressure p_s and piston back pressure p_r can be expressed in terms of v by combining the Bernoulli equation for unsteady state with the continuity equation and rearranging to

$$p_s = p_a - \frac{\rho v^2}{2g}\left[1 + Z_s\left(\frac{A_s}{a_s}\right)^2\frac{x_1}{x} - \left(\frac{A_s}{A_a}\right)^2\right] - \rho\frac{dv}{dt}\left[\frac{A_s l_s}{a_s} + x + \left(\frac{A_s}{A_a}\right)(H_a - H_g)\right] \qquad (7)$$

and

How to Solve a Specific Design Problem

Piston velocity and related performance characteristics of a hydraulic cylinder can be predicted from the physical characteristics of the system.

For many applications, it is necessary only to determine the piston velocity when the system has reached a steady-state condition after the opening of the control valve. In other situations it may be desired to predict performance in the transient period during and just after the opening of the control valve. If the connecting lines are short, elasticity of the system can be disregarded. If the lines are long, the elasticity must be considered to obtain accurate values.

This step-by-step procedure shows how to perform the calculations for each situation. It also explains which approach is required for a given situation.

Given: A load system consisting of force F and mass M to be moved by means of a hydraulic cylinder through a distance x_r in time t_r.

Required: Piston area, rod area, line area, and accumulator pressure.

Steady State

1. The first approach assumes the steady-state condition. As shown in the article text, the actual time for the complete forward stroke is several times greater than the time calculated for steady state. As a first approximation, assume a factor of 2. Therefore, the required steady-state velocity is $v_{st} = 2x_r/t_r$.
2. Calculate system characteristic C_1 from Equation 5. Selection of piston area A_s, piston-rod area A_r, and pipe-line areas a_s and a_r should be based on space and design consideration. The values of resistance coefficients Z_s and Z_r are calculated from standard handbook data.
3. Calculate accumulator pressure p_a from Equation 4. On the basis of this calculated value, select a practical value for p_a. If accumulator pressure p_a is given, rearrange Equation 4 to

$$C_1 = \frac{0.97\,A_s p_a - F}{v_{st}^2}$$

Calculate the value required of C_1. Then adjust the design parameters selected in step 2 to satisfy this new value of C_1.

Transient, Nonelastic System

4. Calculate system characteristic C_2 from Equation 10.
5. The value of piston displacement x_1 at the time t_1 (when the operating valve has just fully opened), can be determined by rearranging Equation 12.

$$x_1 = \sqrt{\left(\frac{C_2}{4C_1}\right)^2 + \frac{(0.97\,A_s p_a - F)(t_1^2/4)}{C_1}} - \frac{C_2}{4C_1}$$

6. Calculate total stroke time t_2 from Equation 14 with $x = x_r$.
7. Compare calculated time t_2 with the value of required time t_r. If necessary adjust piston area A_s, piston-rod area A_r, and line areas a_s and a_r. Then repeat steps 2 through 7 until the required value for t_2 is obtained.
8. Calculate propagation velocity u in the fluid medium from Equation 15 and determine the value of $2l_s/u$.
9. If $2l_s/u$ is small compared to opening period t_1 of the operating valve, then the results obtained are accurate and the problem is solved.

Transient, Elastic System

10. If $2l_s/u$ is large compared to opening period t_1 of the operating valve, solve Equation 21 graphically for the initial condition $t = 0$, $x = 0$, $v = 0$ as shown in Fig. 3. In all cases the solution has the form of curve No. 1 in Fig. 3.
11. Determine graphically the velocities at the abscissa points $t = 2l_s/u$, $4l_s/u$, $6l_s/u$, $8l_s/u$ . . . and points between as indicated in Fig. 3. Draw the velocity curve (Curve No. 2 in Fig. 3). Determine the area under the velocity curve from $t = 0$ to $t = t_1$. This area equals piston displacement x_1 at the end of the first period, when the operating valve has just fully opened.
12. Calculate the total stroke time t_2 from Equation 14 with $x = x_r$, using the new value for x_1 obtained in Step 11.
13. Compare calculated time t_2 obtained in Step 12 with required time t_r. If necessary, adjust piston area A_s, piston-rod area A_r, and line areas a_s and a_r. Then repeat steps 10 through 13 until the required value for t_2 is obtained.

$$p_r = \frac{\rho v^2}{2g}\left[\left(\frac{A_s - A_r}{a_r}\right)^2 (1 + Z_r)\left(\frac{x_1}{x}\right) - 1\right] - \rho h + \frac{\rho}{g}\frac{dv}{dt}\left[\left(\frac{A_s - A_r}{a_r}\right) l_r + (L_c - L_p - x)\right] \quad (8)$$

During the first period, $0 \leqq x \leqq x_1$, the resistance coefficients of the drive and return systems are not constant. They are assumed to follow the expressions $Z_s(x_1/x)$ and $Z_r(x_1/x)$, to show the changing resistance of the operating valve plus the additional starting pressure loss caused by the energy consumption required for the formation of the velocity profile of the flow in the line.

During the second period, $x_1 \leqq x \leqq x_2$, the pressures p_s and p_r are similar to Equations 7 and 8, except that factor x_1/x, because of the varying resistance of the operating valve during the first period, is now $x_1/x_1 = 1$.

Equations 7 and 8 can be substituted into Equation 6. If a_s is considered equal to a_r, and the insignificant terms disregarded, the result can be simplified to

$$0.97\,A_s p_a - F = C_2\frac{dv}{dt} + C_1\frac{x_1}{x}v^2 \quad (9)$$

where

$$C_2 = \frac{\rho}{a_s g}\left[(1.03\,A_s - 0.88\,A_r)(A_s - A_r) l_r + 0.97\,A_s^2 l_s\right] + \frac{G + M}{g} \quad (10)$$

Quantity C_2, contains geometrical and physical quantities pertinent to the drive and load systems. It represents an additional system characteristic.

Piston velocity for the first period for the boundary conditions, between $x = 0$ and $x = x_1$, is:

$$v = \sqrt{\frac{\frac{2}{C_2}(0.97\,A_s p_a - F)x}{K_1}} \quad (11)$$

where

$$K_1 = \frac{2\,C_1 x_1}{C_2} + 1$$

The time-displacement function is:

$$t = \int_0^x \frac{dx}{v} = 2\sqrt{\frac{K_1 x}{\frac{2}{C_2}(0.97\,A_s p_a - F)}} \quad (12)$$

For the second period, piston velocity and time are:

$$v = \sqrt{\frac{0.97\,A_s p_a - F}{C_1}\left[1 - \frac{e^{-K}}{K_1}\right]} \quad (13)$$

where

$$K = \frac{2\,C_1(x - x_1)}{C_2}$$

Then

$$t = t_1 + \sqrt{\frac{C_1}{0.97\,A_s p_a - F}} \times \left[(x - x_1) + \frac{C_2}{C_1} ln \frac{1 + \sqrt{1 - \frac{e^{-K}}{K_1}}}{1 + \sqrt{1 - \frac{1}{K_1}}}\right] \quad (14)$$

The equations developed above now make it possible to calculate the hydraulic pressures, the ve-

Table 1—System Specifications

Cylinder No.	Accumulator Pressure (psi)	Line Length, l_s (ft)	Return Line Length, l_r (ft)	Line Diameter (in.)	Piston Diameter (in.)	Rod Diameter (in.)	Weight of Rod and Piston, G (lb)	Static Force on Piston, F (lb)	Resistance Coefficient, Z_s	Resistance Coefficient, Z_r	System Constant, C_1 (lb sec²/ft⁴)	System Constant, C_2 (lb sec²/ft)
1	2000	12	13	2	4	2¾	85	25,200	52	48	83.2	324.8
1a	1000	13	13	2	4	2¾	85	12,600	52	48	83.2	324.8
2	1000	13	13	1¼	4	2¾	85	12,600	53.5	49.5	581	342.6
3	1000	13	13	1¼	5	2¾	100	19,600	53.5	49.5	2580	397.1
4	1000	13	13	2	6	2¾	120	28,200	52.2	48.2	1260	356.5

Table 2—Calculated Values

Cylinder No.	Steady-State Condition: Head-End Pressure (psi)	Steady-State Condition: Rod-End Pressure (psi)	Steady-State Condition: Piston Velocity, v_{s1} (fps)	Steady-State Condition: Stroke Time, t_2 (sec)	Transient-State Conditions: Head-End Pressure at time t_1 (psi)	Transient-State Conditions: Rod-End Pressure at time t_1 (psi)	Transient-State Conditions: Head-End Pressure at time t_2 (psi)	Transient-State Conditions: Rod-End Pressure at time t_2 (psi)	Transient-State Conditions: Piston Velocity, v_1 (fps)	Transient-State Conditions: Piston Velocity, v_2 (fps)	Transient-State Conditions: Valve Time, t_1 (sec)	Transient-State Conditions: Stroke Time, t_2 (sec)
1	775	320	15.6	0.064	735	340	755	330	3.10	9.9	0.045	0.224
1a	565	115	9.3	0.107	550	125	555	120	1.90	5.9	0.088	0.388
2	590	110	3.5	0.286	560	125	565	111	1.65	3.44	0.100	0.367
3	560	205	2.3	0.435	530	235	560	210	1.68	2.3	0.099	0.504
4	545	270	4.2	0.238	495	310	545	270	2.50	4.2	0.066	0.301

locities in the hydraulic system, the stroke time, the piston speed, and the piston displacement as a function of time.

Practical Examples: Table 1 shows the specifications of five different cylinder systems. In each, the load system has a force $F = 5000$ lb and a mass $M = 10{,}000$ lb. Piston position $x_2 = 12$ in. and $x_1 = 1$ in.

Table 2 shows the calculated operating characteristics for steady-state and transient-state conditions.

As shown in Table 2, cylinder No. 1 is the fastest and No. 3 the slowest. The piston stroke of No. 1 is 2.25 times as fast as No. 3 (0.504/0.224) although the static force on the piston (Table 1) is only 28 per cent greater for No. 1 than for No. 3 (25,200/19,600 = 1.28). The piston stroke of No. 1 is 35 per cent faster than that of No. 4, even though the static force on piston No. 4 is 12 per cent greater than on No. 1.

Variation of the supply and return pressures during the stroke is also shown in Table 2. Supply pressure rises steeply at the beginning of the stroke and then approaches gradually the steady-state value. Return pressure at the beginning of the stroke exceeds the steady state value, then gradually decreases toward the steady-state value.

Table 2 also shows that the actual time for the complete forward stroke for the five arrangements is 1¼ to 3½ times greater than the time calculated for steady state.

Transient Condition, Elastic System

The propagation velocity of a pressure or velocity variation, caused, for example, by the opening of a valve equals the velocity of sound:

$$u = \sqrt{\frac{g}{\rho\left(\frac{1}{E_f} + \frac{d_s}{E_l s}\right)}} \qquad (15)$$

The fluid velocity and pressure in a section, l, of the line, Fig. 2, can be expressed generally as:

$$c = k_1 - \frac{1}{u}\left[F_1\left(t - \frac{l}{u}\right) + F_2\left(t + \frac{l}{u}\right)\right] \qquad (16)$$

and

$$p = k_2 - \frac{\rho}{g}\left[F_1\left(t - \frac{l}{u}\right) - F_2\left(t + \frac{l}{u}\right)\right] \qquad (17)$$

Constants k_1 and k_2 are determined by the initial condition. The values of functions F_1 and F_2 are determined by the boundary conditions. The boundary conditions at the valve, $l = 0$, and at the accumulator, $l = l_s$, must be defined.

During cylinder operation, the disturbance originates at $l = 0$ and propagates in the positive direction until it reaches the accumulator. It is then reflected and propagates in the negative direction until it reaches the valve. Then it is reflected again. It is difficult to express the boundary conditions in closed form which is valid for the complete first period of the piston operation. However, the boundary conditions can be expressed for consecutive intervals of time. In general, these intervals are multiples of $2(l_s - l)/u$, because this is the time required for a wave to propagate from a section l to the accumulator and back to l again. For section $l = 0$, this time interval is $2l_s/u$.

Therefore, the first interval is $0 \leqq t < 2l_s/u$. For $l = 0$, function F_2 is nonexistent during the first time interval. Therefore Equations 16 and 17 can be simplified to

$$c_v = \frac{1}{u} F_1(t) \qquad (18)$$

and

$$p_v = p_a - \frac{\rho}{g} F_1(t) = p_a - \frac{\rho u c_v}{g} \qquad (19)$$

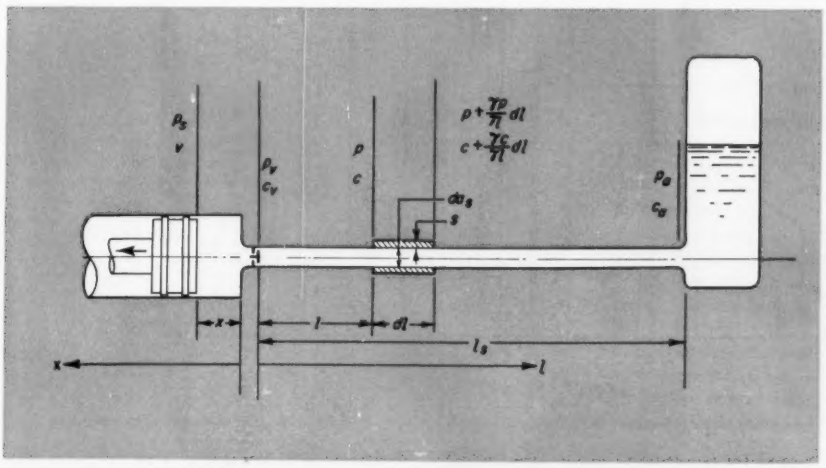


Fig. 2—Transient conditions in an elastic system hydraulic circuit.

Piston velocity is

$$v = \frac{a_s}{A_s u} F_1(t) \qquad (20)$$

The boundary condition at the valve can be combined with Equation 6 and Equation 20 to give the differential equation of the piston motion for the time interval $0 \leqq t < 2l_s/u$.

$$\left(C_2 - \frac{0.97\, A_s^2 l_s \rho}{a_s g} \right) \frac{dv}{dt}$$

$$= 0.97\, A_s p_a - F - \frac{0.97\, A_s^2 \rho u v}{a_s g} - C_1 \frac{x_1}{x} v^2 \qquad (21)$$

This differential equation is the basis for a graphical method to determine the piston velocity and displacement as a function of time. The equation cannot be solved in closed analytical form. Therefore, a numerical or graphical solution must be used. This solution must satisfy the initial condition $t = 0$, $x = 0$, $v = 0$. For cylinder No. 1 of Table 1, this solution is shown as curve No. 1 in Fig. 3. The numerical value of $2l_s/u$ is 0.008 sec. Therefore, the solid line portion of curve No. 1 is the piston velocity-time function for the first interval of the first period.

The second interval is $2l_s/u < t < 4l_s/u$. For this time interval, the function F_2, representing the influence of the wave reflected at the accumulator, is no longer zero. The piston velocity function is now

$$v = \frac{a_s c_{01}}{A_s} + \frac{a_s}{A_s u} F_1(t) +$$

$$\frac{a_s}{A_s u} F_1\left(t - \frac{2l_s}{u} \right) \qquad (22)$$

The second term in Equation 22 is identical with the right side of Equation 20 which, in turn, equals the ordinates of curve No. 1 in Fig. 3. The third term in Equation 22 is the ordinate of curve No. 1 at time $t - (2l_s/u)$ that is $2l_s/u$ seconds earlier. These relationships permit the simple graphical method for plotting piston velocity v shown in Fig. 3. The area under the heavy-line velocity curve equals the displacement

$$x = \int_0^t v\, dt$$

Subsequent intervals are: $nl_s/u < t < (n + 2)\, l_s/u$ where $n = 4, 6, 8 \ldots$ The solutions are similar to that outlined for the second interval. The values are shown in Fig. 3.

The results of the numerical evaluation vary less than 3 per cent from the values obtained when the elasticity considerations were disregarded.

This similarity of results between the two methods is not necessarily true for all arrangements. The Bernoulli equation for unsteady state and the wave equations produce comparable results only when the line lengths are short compared to the wave-propagation velocity. Thus, $2l_s/u$ is small compared to the opening time of the operating valve.

The opening time of solenoid valves usually used for this type of application is about 0.1 sec. In these cases, the elastic phenomena may be disregarded. Solutions based on the Bernoulli equation for transient conditions produce sufficiently accurate results.

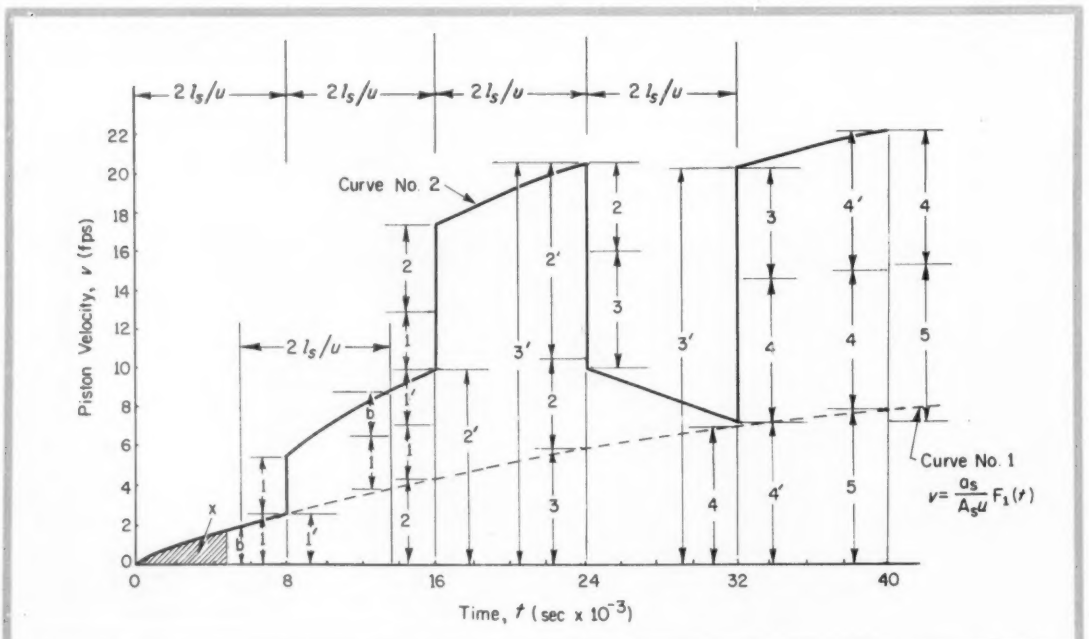


Fig. 3—Graphical method for determining piston velocity and displacement as a function of time.

How to determine critical buckling loads for

Columns Loaded Between Supports

JAMES DOW
Boston, Mass.

VARIOUS methods are available for determining critical buckling loads for columns loaded axially at their ends. However, these methods cannot be used, without modification, if the load is applied axially at a point between the end supports. This article presents a quick method of finding the critical buckling load of a pivot-ended column which is axially loaded between the end points. The column is assumed to be uniform in cross section, with the load applied through the centroid of the section.

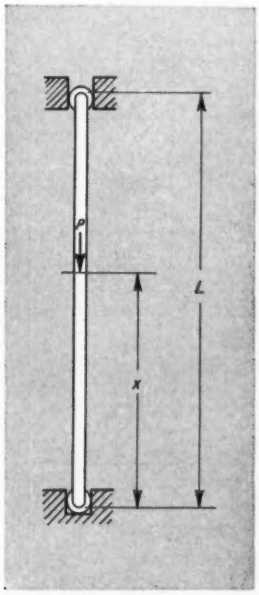


Fig. 1—Typical column, pivoted at top and bottom and free to move axially at top, with load applied as shown.

Method: Euler's formula for determining the critical buckling load for an end-loaded, pivoted (pinned) column is

$$P_{cr} = \frac{\pi^2 E I}{L^2} \qquad (1)$$

Where a column is loaded at a point other than the end supports, Fig. 1, this formula becomes

$$P_{cr} = \frac{\pi^2 E I}{L_R{}^2} \qquad (2)$$

where L_R, the reduced length, is the length of a con-

Nomenclature

A =	Cross-sectional area of column, sq in.
E =	Young's modulus of elasticity, psi
I =	Minimum moment of inertia, in.^{4}
L =	Length of column, in.
L_R =	Reduced length of column, in.
P =	Applied load, lb
P_{cr} =	Critical buckling load, lb
S_y =	Yield Stress, psi
x =	Distance from load point to bottom of column, in.
σ_c =	Compressive stress, psi
σ_{cr} =	Compressive stress under critical buckling load, psi
σ_{scr} =	Maximum shear stress under critical buckling load, psi.

ventionally loaded column—pinned at both ends and of the same material and cross-sectional dimensions—which has the same critical buckling load as the column loaded between supports.

Values of L_R may be obtained by using the graph in Fig. 2, which relates x/L to L_R/L. Ratio x/L is first calculated from known data. After the ratio L_R/L has been taken from the graph, it is multiplied by column length L to obtain L_R. Equation 2 can then be used to determine critical buckling load.

General Considerations: This method assumes that the column is long, and will collapse by buckling in the direction of the minimum radius of gyration, rather than by fracturing from excessive compressive stress. Usually, a steel column is considered "long" if its slenderness ratio, L/r, is more than 150.

A more accurate method of determining whether a beam will buckle or fracture is to calculate the stress in the column when the critical load is applied. Compressive stress $\sigma_{cr} = P_{cr}/A$, where P_{cr} is the calculated critical buckling load.

If σ_{cr} is greater than the yield stress, S_y, of the column material, the column is not long and may fracture before it buckles. The column should then be designed so that the compressive stress, $\sigma_c = P/A$, is less than the yield stress.

It has been determined experimentally that columns made of certain materials tend to crack along a plane of maximum shear. If the maximum acceptable shear stress for the material is known, and it is less than $\sigma_{scr} = P_{cr}/2A$, the column is not long and will fracture before it buckles.

EXAMPLE: Assume that a column is a 3-in. steel channel, 10 ft long, supported as in Fig. 1, and loaded axially at a point 6 ft from the base. The load is applied as shown in Fig. 1. Minimum moment of inertia of the column is 0.20 in.^{4} and the cross-sectional area is 1.21 sq in. Find the critical buckling load.

Calculate ratio $x/L = 6/10 = 0.6$. From the graph, $L_R/L = 0.74$. Then, $(L_R/L)\,L = 0.74 \times 10 = 7.4$ ft $= 88.8$ in. Finally, $\pi^2EI/L_R^2 = (3.14)^2 (29 \times 10^6)\,(0.20)/(88.8)^2 = 7240$ lb.

To establish whether or not the column is long, $\sigma_{cr} = P_{cr}/A = 7240/1.21 = 6000$ psi. Since $\sigma_{cr} = 6000$ psi $< S_y = 38{,}000$ psi, the column is long.

Theory: Data for the graph in Fig. 2 were calculated with an electronic computer, the program being written in the Bell II language for an IBM 650. The graph represents solutions of a transcendental eigenvalue equation arising from a theoretical analysis of the problem. The theory of bending in beams with small deflections was used. This assumes $d^2y/dx^2 = -M/EI$ along the axis of the beam.

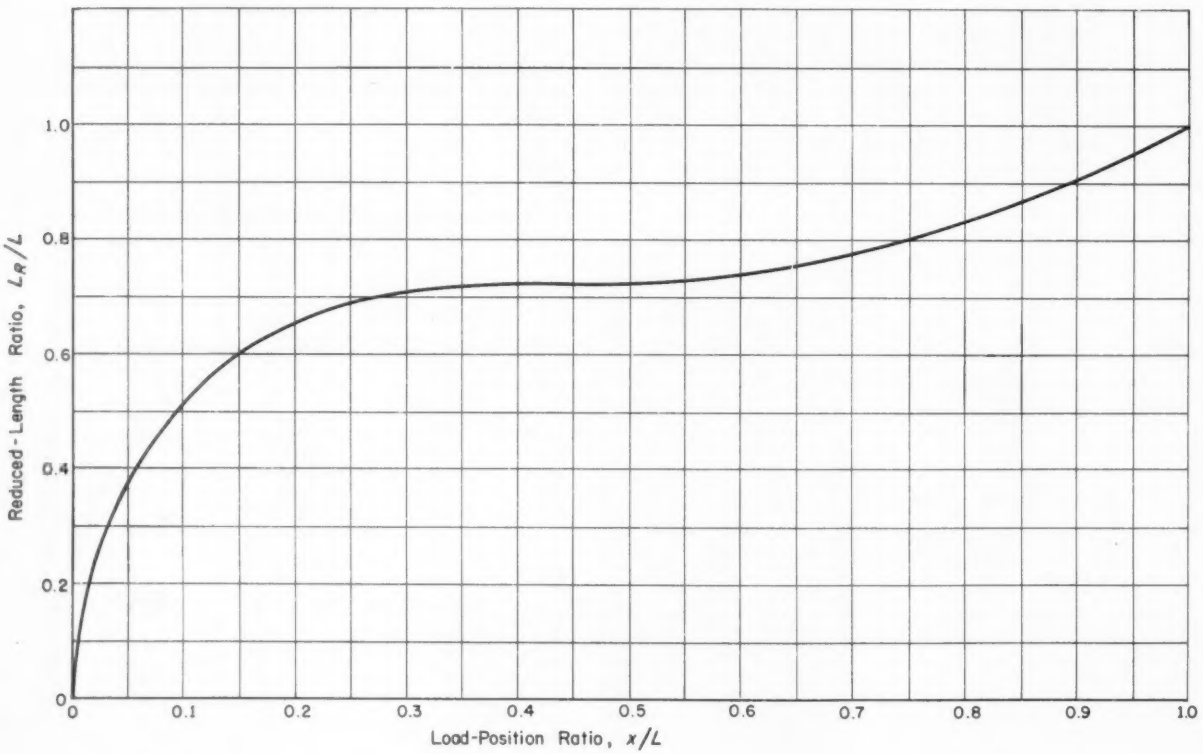


Fig. 2—Graph for determining L_R/L values for columns loaded at a point other than the end supports.

FASTENOMICS

TIPS ON FASTENER APPLICATIONS BY STANSCREW

Socket Screw Standards Changed

Check Dimensional Revisions Now to Avoid Extra Costs

Important changes are now in progress in the socket screw industry. Every user should know the details and take appropriate action to avoid higher costs in the future. As a public service, Stanscrew is issuing this progress report.

New Standards Adopted

Exhaustive industry-wide studies, begun in 1954, culminated in 1959 with the adoption of new dimensional standards for socket head cap screws. Standard Screw participated in these studies and concurred in industry recommendations. The new standards, known as the "1960 Series", include changes in head diameters, socket sizes, and thread lengths.

Advantages of New Design

The "1960 Series" has been carefully engineered so there is functional uniformity for all sizes, particularly as applied to wrenching areas and to the relationship of head diameters to body diameters. It offers these important advantages over the previous design, known as the "1936 Series":

1. Larger wrenching area permits applications of clamping force . . . provides maximum utilization of fastener's inherent strength.
2. Provides increased bearing surface under the head . . . up to 233% more.
3. Minimum indentation . . . particularly important with softer metals.

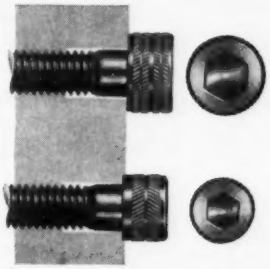
What's Available When

When the "1960 Series" was announced in 1959, it was believed it would become the only standard as of Jan. 1, 1961 and, thereafter, all "1936 Series" would be available only on special order. As previously announced, all sizes in the "1960 Series" are being supplied as standard. However, to make the transition as easy as possible, Stanscrew and other leading producers have extended the changeover period for certain sizes of the "1936 Series".

These are the sizes . . . 5/16", 7/16", 5/8", 3/4", 7/8" and 1" . . . for which the new standards include a change both in head diameter and socket width across flats. Until Jan. 1, 1963 both the "1936 Series" and "1960 Series" will be considered standard in these six sizes.

For all sizes, however, thread lengths are now being manufactured to "1960" standards. Once current inventories are depleted, "1936 Series" thread lengths will be available on special order only. Based on exhaustive surveys, this will prove no problem in the overwhelming majority of applications.

In some sizes . . . #1, #2, #4, #6, and #8 . . . head diameters are the same, but there has been a change in the socket width. In these sizes, current production is to "1960 Series" dimensions. These sizes are also available in the "1936 Series" until present stocks are depleted, but thereafter only on special order.



Change In Your Designs Essential

This industry program makes it essential that you review product designs to avoid future difficulties. All products now on your drawing boards should incorporate the "1960 Series" socket cap screws wherever possible. And, during the next two years, it is recommended you take advantage of model changes or other opportunities to change existing applications of the "1936 Series" to the "1960" standards. Failure to make provisions could result in procurement difficulties or the higher costs of non-standard items.

Complete Design Information Available

Stanscrew has prepared an up-to-date brochure giving complete information on all steps in this important transition, together with complete design data on both the "1960" and "1936 Series". You can obtain your copy through your local Stanscrew distributor. Call him today.

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Recent developments in

Adhesive Bonding

of structural assemblies

FRANK J. RIEL
Narmco Industries Inc.
San Diego, Calif.

RESEARCH on adhesive systems for bonding of structural metal components has resulted in the development of two general types of adhesives—those intended primarily for bonding continuous metal skins to each other, and those intended primarily for attaching metal skin to honeycomb sandwich core. These two distinct classes, developed to their ultimate, are not interchangeable.

Unfortunately, most sandwich construction contains areas where metal-to-metal bonds are necessary. Hence, the sandwich fabricator must accept less than optimum performance in some portions of his bonded assembly, or use two adhesive systems in each part; that is, one adhesive for metal-to-metal areas and another adhesive for sandwich areas.

Two recent developments mark the search for a single ideal adhesive:

1. A dry phenolic resin was blended with a nitrile rubber, and sheeted into a thin, dry film. This type of adhesive, used in conjunction with a solvent-adhesive blend as a primer, offers an excellent combination of properties. By minor modifications of curing agent and resin ratios, a whole family of phenolic-nitrile systems are available.
2. A more recent adhesive development, the phenolic-epoxy system, is currently used for both metal-to-metal and sandwich applications. This class of materials exhibits good strength retention up to 500 F, hence is used where these extreme operating conditions exist. However, performance in other areas suffers, and this type of adhesive is not outstanding except for high-temperature resistance.

The development of sandwich adhesives thus far has been more of a physical form modification than a materials development, since the materials used in sandwich adhesives generally have been the same as those used in metal-to-metal adhesives. Unlike metal-to-metal bonding, where pressure is always used, the sandwich bond must form without pressure, since the main part of the bond consists of the fillet formed at the base of the metal foil which makes up the honeycomb core. The amount of adhesive trapped between the edge of the core and the skin is too small to contribute any significant strength to the joint. Therefore, the formation of a fillet around the base of the core is necessary if the adhesive is to produce a satisfactory joint.

Up to the present time, most structural sandwich adhesive systems have the following common characteristics:

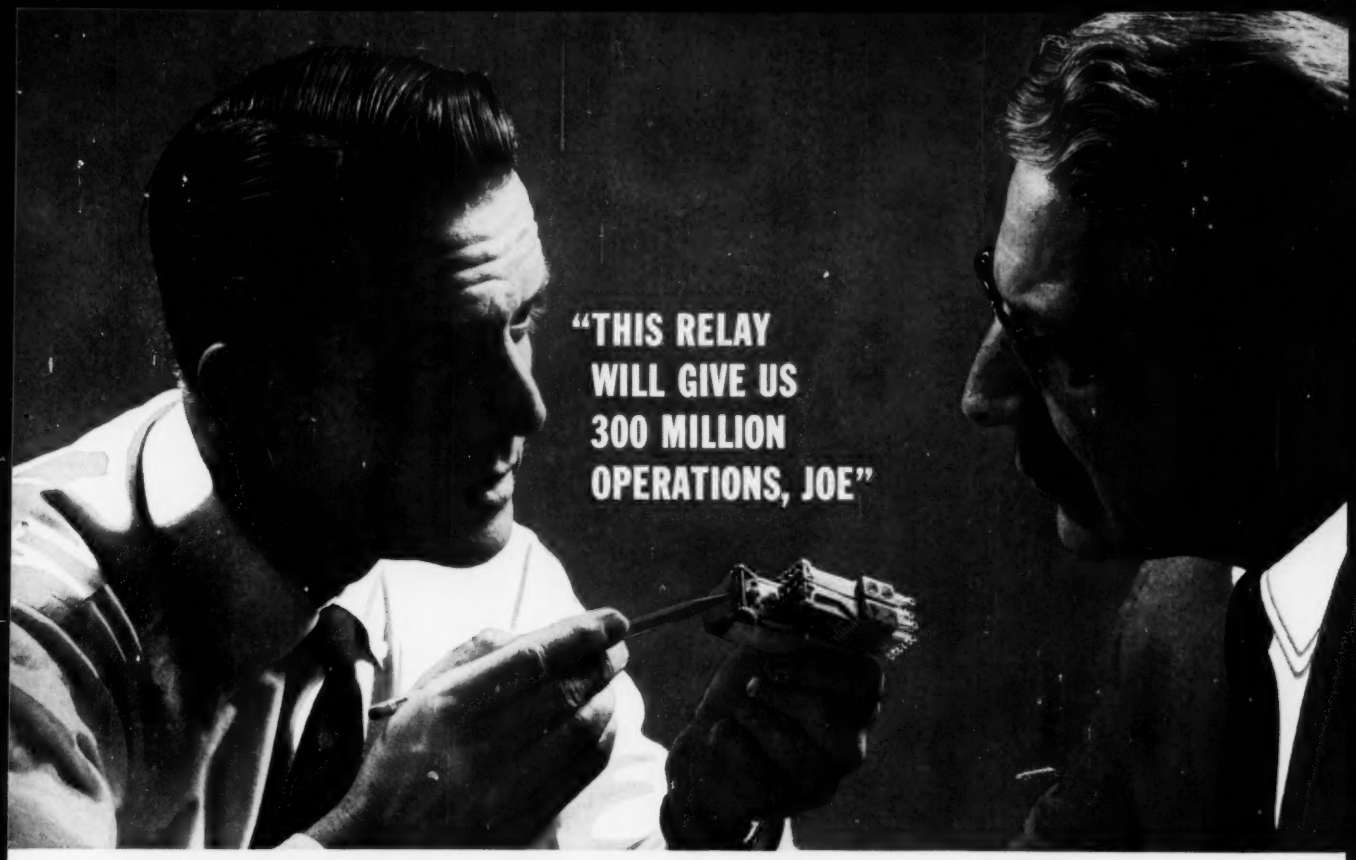
1. They consist of non-homogeneous blends of two or more resin systems.
2. They contain a fabric carrier.
3. They contain phenolic resins blended with an elastomer.

These characteristics have become accepted as the proper make-up for a sandwich adhesive. However, it was suggested that the asymmetric film containing the carrier was not really the ultimate in sandwich-adhesive design. If a single material could be developed having the desired viscosity, wetting characteristics, curing cycle, and cured physical strength, it was considered likely that it would perform satisfactorily without the use of a special filleting layer, and without a fabric carrier. Furthermore, it should perform equally well in sandwich and metal-to-metal applications.

Because of the past difficulties encountered in using phenolic resins in structural adhesives, it was decided to attempt to develop an epoxy resin system with the desired degree of elasticity. After a series of screening tests, the nylon-resin systems were chosen for a more extensive evaluation in combination with certain epoxy resins. Results of this study indicate that a whole family of new adhesive systems, consisting of blends of epoxy-nylon resins, can be prepared. Within certain ranges, a variety of unique adhesive properties can be achieved.

General characteristics of a typical member of this group can be observed by comparison of physical properties with the requirements of appropriate military specifications, Table 1. It can be seen that, from the standpoint of military specifications, superior adhesive systems can be formulated from epoxy-nylon combinations.

However, compliance with military specifications does not fully describe the characteristics of structural adhesives. A great many other questions remain: Allowable curing conditions, flow characteristics, adhesive weight, ability to form large area bonds without blistering, ability to bond materials other than alu-



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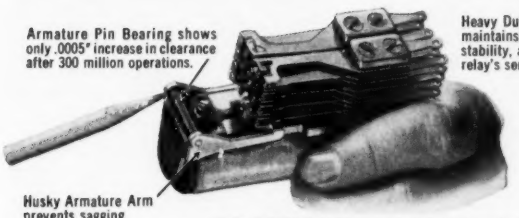
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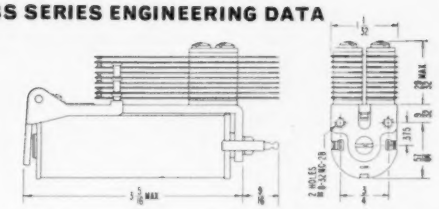


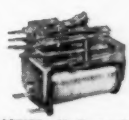
GENERAL:
- **Breakdown Voltage:** 1000 volts rms 60 cy. min. between all elements.
- **Ambient Temperature:** −55° to +85° C. +125° C available on special order.
- **Weight:** 9 to 16 ozs.
- **Terminals:** Pierced solder lugs; Coil: One #16 AWG wire Contacts: Two #18 AWG wires
- **Enclosures:** Dust covered or sealed

CONTACTS:
- **Arrangements:** DC—up to 28 springs AC—up to 24 springs
- **Material:** 1/16" dia. twin palladium. Up to 1/4" dia. single silver. Other materials on special order.
- **Load:** 4 amps at 115 volts, 60 cycle resistive
- **Pressure:** 15 grams minimum

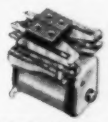
COILS:
- **Resistance:** 100,000 ohms maximum Current: 10 amps maximum
- **Power:** DC—50 Milliwatts per movable arm. Greater sensitivity on special order. AC—17.9 volt-amps.
- **Duty:** Continuous
- **Treatment:** Centrifugal impregnation
- **Voltages:** DC—up to 300 volts with series resistor. AC—up to 250 volts, 60 cy.

MOUNTING: Two #8-32 tapped holes 3/4" o.c. Other mountings on special order.

GS SERIES—Excellent sensitivity: 50 mw per movable arm minimum (DC). For applications requiring many switching elements in small space.



LS SERIES—Medium coil relay with short springs and light weight armature for fast action, reliability and long life.



TS SERIES—Short coil relay is available in AC and DC versions. Long life construction. Can be supplied (DC) with up to 20 springs (10 per stack).

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Circle 483 on Page 19

Table 1—Properties of a Typical Epoxy-Nylon Resin Adhesive

Percent of Military Specification Requirement	0	100	200	300
Properties required by specification MIL-A-5090B				
Tensile shear at:				
Room temperature				
−67 F				
180 F				
Room temperature tensile shear after exposure of:				
30 days salt spray				
7 days tap water				
7 days anti-icing fluid				
7 days hydraulic oil				
Room temperature blend strength				
Room temperature creep				To 720 per cent
Creep at 180 F				To 1500 per cent
Properties required by specification MIL-A-25463				
Climbing drum peel strength at:				
Room temperature				To 665 per cent
−67 F				To 880 per cent
180 F				To 695 per cent
Flexural strength at:				
Room temperature				
−67 F				
180 F				
Flexural strength after 192 hours at 180 F				
Room temperature flexural strength after 30-days exposure to:				
Salt spray				
100 per cent relative humidity at 120 F				
Hydrocarbon				
Flatwise tensile strength at:				
Room temperature				
−67 F				To 352 per cent
180 F				
Room temperature creep				To 500 per cent
Creep at 180 F				

minum, surface conditions necessary for bonding, shelf-life characteristics, and general handleability during the bonding process.

Epoxy-nylon adhesives, like other adhesive systems, can be prepared in various forms. Best results have been obtained with dry films, although solvent blends can be prepared. This type of adhesive is simply interposed between the metal or other surfaces to be bonded, pres-

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Circle 484 on Page 19

surized to cause the parts to come together, heated, and cured. No metal primer is necessary, although one can be used if desired. A typical cycle is one hour at 350 F and 25 psi.

One of the unique characteristics of the epoxy-nylon films is their ability to provide high-strength sandwich bonds at lighter adhesive film weights than previously used. In general, film weights of 0.05 psf are adequate, whereas conventional adhesives usually require 0.08 to 0.10 psf.

Performance of these lightweight adhesives is a result of their unique ability to form fillets which utilize all of the adhesive, Fig. 1. During the early stages of the cure cycle, 150 to 250 F, the film softens and becomes very weak, but does not actually melt. Residual stresses resulting from the processing technique cause the film to shrink, separate, and gather at the points of contact between the cell wall and the skin.

Up to this temperature, the adhesive is still in a dry, non-tacky form. As the temperature increases, the film softens further, becomes tacky, and, at approximately 300 F, melts and wets the metal surfaces to be bonded, and forms a fillet. The cure is completed at 350 F.

This unique filleting action causes all of the adhesive to locate itself in the fillet area, leaving bare metal elsewhere on the skin. In metal-to-metal bonds, relatively low pressures are adequate. Vacuum bag pressure and mechanical clamps have been used successfully. In general, pressure required to bring the metal parts into a complete contact will be sufficient to effect a high-strength bond. Typical metal-to-metal glueline thicknesses are 0.001 to 0.002 in.

Although epoxy-nylon adhesives are by nature relatively high-flow materials, their thixotropic characteristics are such that they can accommodate themselves to both low and high-pressure bonding.

By selection of the proper ratio of epoxy to nylon, the physical properties of the cured system are such that an exceptionally high peel strength can be achieved. For example, metal-to-metal T-peel strength values (0.020 in. thick skins) well in excess of 100 in.-lb per in. width can be achieved. Sandwich peel strength is a function of tape weight.

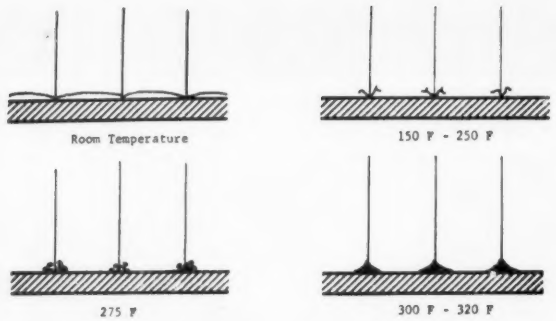


Fig. 1—Curing cycle of epoxy-nylon adhesives.

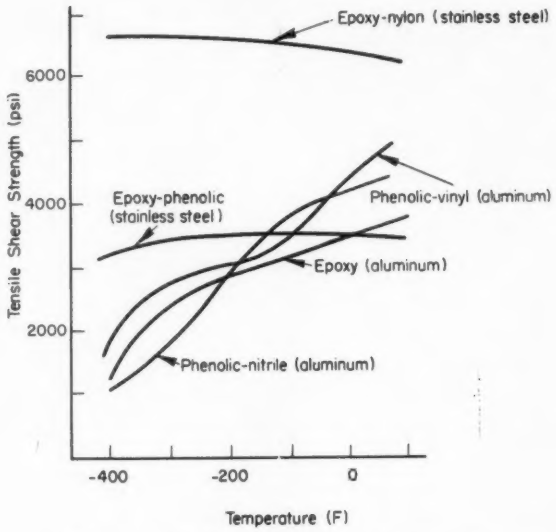


Fig. 2—Strength of adhesives at high temperatures.

Because of the very high peel strength available with epoxy-nylon adhesives, long overlap bonds show less decrease in strength of bonded area than other adhesives, Table 2.

Unlike phenolic-elastomer adhesive systems, epoxy-nylon systems do not exhibit a sharp freeze point where they lose their elasticity. Consequently, epoxy-nylon systems exhibit outstanding retention of strength at very low temperatures, Fig. 2. Epoxy-nylon systems investigated thus far are operational over the temperature range of −400 to 200 F.

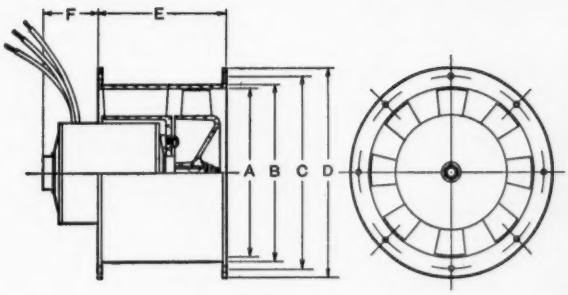
Epoxy-nylon adhesive systems have excellent wetting characteristics, and will bond to a variety of metal surfaces. Titanium bonds show tensile shear strength in excess of 5000 psi. Magnesium and aluminum can be bonded without surface treatment other than a solvent wipe.

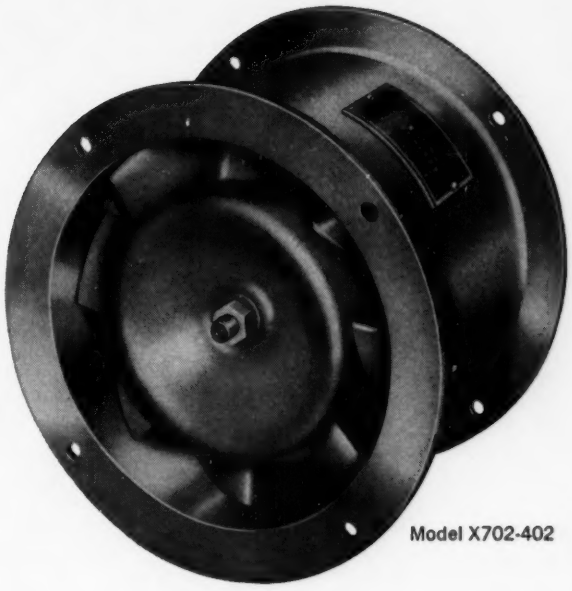
Table 2—Strength of Bonded Area

Metal Thickness (in.)	Overlap (in.)	Tensile Shear Stress at 200 F (psi)
0.064	0.25	4400
0.064	0.50	5000
0.064	1.50	metal failure
0.080	1.00	2980
0.080	1.25	2660
0.080	1.50	2340
0.080	1.75	2220
0.080	2.00	2540
0.080	2.25	2260
0.080	2.50	metal failure
0.125	2.50	2250
0.125	3.00	2266
0.125	3.50	1980
0.125	4.00	1930
0.125	4.50	1800

Shear strength in excess of 4000 psi can be obtained under these conditions. The surface condition of aluminum etched by the conventional sodium dichromate-sulfuric acid does not seem to be as critical for epoxy-nylon systems as it is for other adhesives.

SPE Paper No. 27-2, "Adhesive Bonding, A New Concept in Structural Ad-





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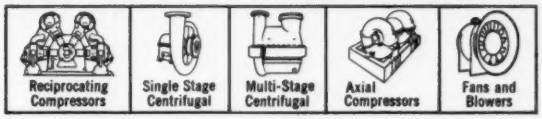
Model No.	Design CFM ±3%	Max. CFM at Free Flow	Design PS ±7%	Max. Pressure	Motor Data		Mechanical Dimensions (Inches)						Holes Per Flange	Total Weight Pounds
					BHP	CAP* MFD	A	B	C	D	E	F		
X702-401	50	70	0.35	0.45	.005	NONE	4.37	4.62	5.25	5.87	4.50	1.00	4	5.25
X702-402	100	145	0.35	0.60	.010	NONE	5.12	5.37	6.00	6.62	4.50	1.00	4	5.85
X702-403	150	205	0.35	0.80	.015	NONE	5.62	5.87	6.50	7.12	4.50	1.00	4	6.1
X702-404	200	265	0.50	0.79	.035	5	5.62	5.87	6.50	7.12	5.00	1.66	8	7.2
X702-405	250	330	0.50	0.82	.043	5	5.87	6.12	6.75	7.37	5.00	1.66	8	7.4
X702-406	300	410	0.50	0.93	.052	5	6.12	6.37	7.00	7.62	5.00	1.66	8	7.6
X702-407	350	490	0.50	0.95	.060	5	6.37	6.62	7.25	7.87	5.00	2.16	8	8.4
X702-408	400	590	0.50	1.07	.068	5	6.62	6.87	7.50	8.12	5.00	2.16	8	8.6
X702-409	450	650	0.50	1.05	.075	5	6.87	7.12	7.75	8.37	5.00	2.16	8	8.8
X702-410	500	735	0.50	1.15	.083	5	7.12	7.37	8.00	8.62	5.00	2.16	8	8.9

*Rated 236 WVAC—

AIR MOVING EQUIPMENT FOR ALL INDUSTRY



JOY

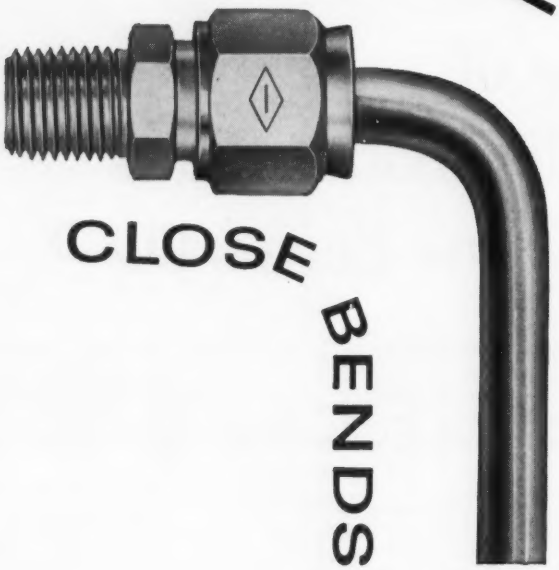
Joy Manufacturing Company
Oliver Building, Pittsburgh 22, Pa.

In Canada: Joy Manufacturing Company (Canada) Limited, Galt, Ontario

Circle 485 on Page 19

no problems with...

CLOSE BENDS

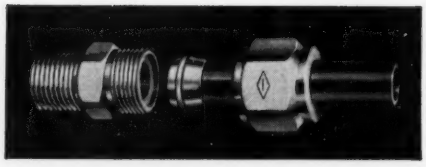


CLOSE BENDS

With Hi-Seal® fittings you can make tube bends close to the fitting—in fact, right next to it. Here Hi-Seal is in a class by itself.

Hi-Seal's simplified design with flareless butt joint makes this possible. The advantages? More compact layouts. Save on tubing. Shorten installation time by as much as 50%. Gain utmost reliability. SAVE MONEY. To get these advantages, insist on Hi-Seal.

For complete information, write for Bulletin 3108.



BUTT JOINT **HI-SEAL**

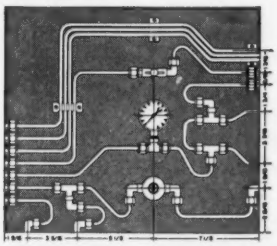
IMPERIAL EASTMAN

Imperial-Eastman Corporation General Offices: 6300 West Howard Street, Chicago 48, Illinois

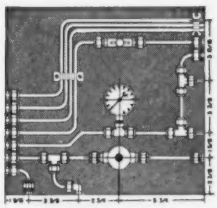
In Canada: Imperial-Eastman Corporation (Canada) Ltd., Toronto

Close Bends with Hi-Seal Save Time, Space, Tubing

Look at what you can do when you use Hi-Seal fittings:



This typical layout has "old-fashioned" tube fittings. Layout area, 257 sq. in.; 12.7 ft. of tubing; *installation time 2 hr., 34 min.*



Same layout with Hi-Seal tube fittings. Layout area reduced 32% to 175 sq. in.; tubing reduced 40% to 7.7 ft.; *installation time reduced nearly 50% to 1 hr., 20 min.!*

All this is possible because of Hi-Seal's exclusive flareless, butt joint design. This means that tube bends may be made right next to the fittings. Even direct tube connections may be made without any extra loops to allow for tube entry into the fitting.

One Fitting for the Entire System

However varied your requirements may be, Hi-Seal meets them. Available in all styles, sizes and combinations, plus a variety of metals: steel, stainless steel, brass, aluminum, titanium, Monel, etc.

Now Imperial-Eastman meets all your requirements for hydraulic-pneumatic-flow system components: tube fittings, valves, couplings, flexible and rigid hydraulic and pneumatic hose, thermoplastic tubing, tubing tools.

FITTINGS

IMPERIAL-EASTMAN

hesives," presented at the Seventeenth Annual Technical Conference of the Society of Plastics Engineers, Washington, D. C., Jan., 1961, 4 pp.

management

Equipment for Information Storage and Retrieval

A. F. Glimn and R. D. Greenway, General Electric Co., Bethesda, Md.

Factors involved in evaluating and specifying equipment and equipment configurations for information storage and retrieval systems. Machines alone can never solve the fundamental problems of information storage and retrieval. They can only provide the means for implementing solutions which would not have been practical using manually operated systems. Thus, the solution to the problem of evaluating and specifying equipment for information storage and retrieval systems must be evolved by conducting a complete and exacting operations analysis study to determine the system parameters.

AIEE Paper No. CP 60-1205, "Information Storage and Retrieval, Part II—Equipment Applications," presented at the AIEE Fall General Meeting, Chicago, Ill., October, 1960, 8 pp.

bearings

Gas-Lubricated Full-Journal Bearings

A. A. Raimondi, Westinghouse Research Laboratories

Numerical solutions of Reynolds' equation pertaining to the finite length journal bearing with a constant unidirectional load and lubricated with a compressible fluid. Results are tabulated for the constant viscosity, isothermal case for L/D values of 2, 1, and ½ and design charts applicable over the full range of the compressibility number are presented for eccentricity ratios ranging from 0.1 to 0.8. Differences between gas and liquid lubricated bearings are mentioned and the numerical techniques employed discussed. Use of the design charts is illustrated, and the numerical results are compared with an existing approximate ana-

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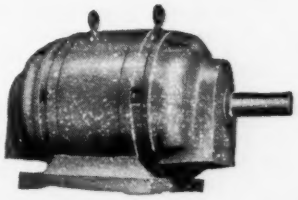
BALL BEARING MOTORS

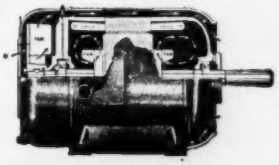
HERE'S WHY . . .

First of all they are specifically engineered to meet the exacting requirements of most power needs — regardless of type or location. Then too, they insure constant, uninterrupted service in high temperatures because they are always cool running. Having enclosed ball bearings you are assured of complete protection against harmful dust and grit. Furthermore, they can handle most power load emergencies without damage to its operating parts.



FAN COOLED

Totally enclosed VALLEY Motor Polyphase, 50 to 60 cycles, constant speed, continuous duty, squirrel cage induction, high torque, low starting current and fully ball bearing, 2 to 60 h.p.



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lytical solution and some test results available in the literature.

ASLE Paper No. 60 LC-14, *"A Numerical Solution for the Gas Lubricated Full Journal Bearing of Finite Length," presented at the ASLE/ASME Lubrication Conference, Boston, Oct.,* 1960, 23 *pp.*

Externally Pressurized Spherical Gas Bearings

J. H. Laub and R. H. Norton Jr., California Institute of Technology

An analytical and experimental study of externally pressurized spherical gas bearings with orifice regulation, and experimental findings, which are in good agreement with the predictions of the viscous flow theory. Spherical gas-lubricated bearings are of considerable interest in applications requiring a pivoting or rotating support with three degrees of freedom.

ASLE Paper No. 60 LC-16, *"Externally Pressurized Spherical Gas Bearings," presented at the ASLE/ASME Lubrication Conference, Boston, Oct.,* 1960, 9 *pp.*

mechanical

Backing of Cylindrical Shells Under Pure Bending

Paul Seide and V. I. Weingarten, Space Technology Laboratories Inc.

Investigation which shows that, contrary to commonly accepted theory, the maximum critical bending stress is, for all practical purposes, equal to the critical compressive stress.

ASME Paper No. 60-WA-33, *"On the Buckling of Circular Cylindrical Shells Under Pure Bending," presented at the Winter Annual Meeting, New York, Nov.-Dec.,* 1960, 5 *pp.*

Behavior of Drums and Linings In Clutches and Brakes

Rolf W. Lange, supervisor, Brake and Clutch Testing, American Brake Shoe Co.

Factors in the matching of drums and linings in the search for the ideal braking combination, and the conditions under which friction pairs are required to operate. Braking is concerned with not only a nominal coefficient of friction and resistance to wear, but with drum treatment insofar as scoring, spotting, cracking, polishing and wear

are concerned; lining stability over a wide range of temperatures, pressures, and speeds; and engagement characteristics, including torque curve shape, tendency of the combination toward chattering or squeal, and other properties.

Emphasis is placed on the word "combination" because the best lining for a particular job may prove to be disappointing if used with a poorly made or improperly selected drum. The converse is equally true. The correct choice of a friction pair is a compromise, and cost is usually an important factor in this compromise.

SAE Paper No. 224C, "Excavator Clutches and Brakes, Behavior of Drums and Linings," presented at the SAE National Farm, Construction, and Industrial Machinery Meeting, Milwaukee, Sept., 1960, 13 pp.

V-Belt Tension Variations In Locked-Center Drives

K. G. Hornung, assistant professor of mechanical engineering; S. M. Marco, professor and chairman of mechanical engineering; and W. L. Starkey, professor of mechanical engineering, Ohio State University

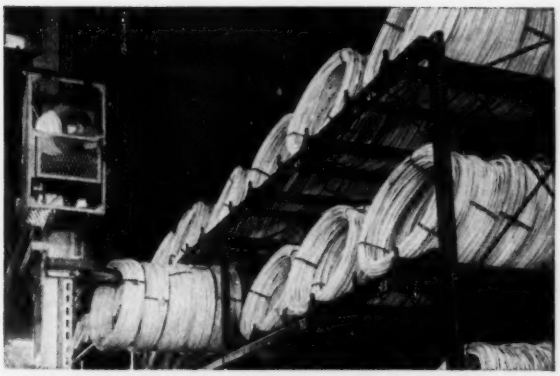
A detailed study of the various physical phenomena involved in the establishment of the belt tensions in a V-belt drive operated at high speed and under a torque load while the pulley-center distance is held constant. In the course of the study, the equation of the belt curve between pulleys is derived. This equation is then integrated to give the free length of belt included between the pulleys. Experimental results are given and indicate excellent agreement between predicted and measured tensions.

ASME Paper No. 60-WA-307, "Tension Variations in V-Belts Applied to Locked-Center Drives," presented at the Winter Annual Meeting, New York, Nov.-Dec., 1960, 8 pp.

Kinematics of a System of Two Hooke's Joints

R. E. Philipp, instructor of ordnance engineering, Dept. of Ordnance, U. S. Military Academy

Analysis to arrive at a general solution to the kinematic behavior of a system of two Hooke's joints. The solution is used to prove the condition which must be satisfied to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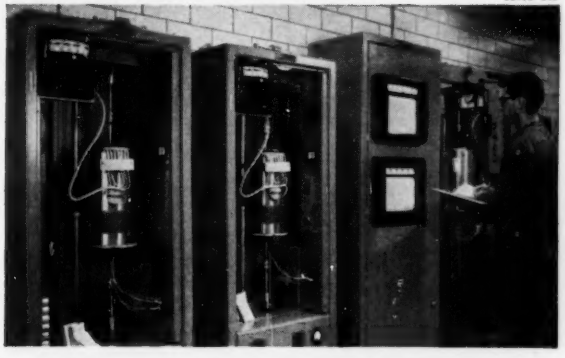
FROM START TO FINISH



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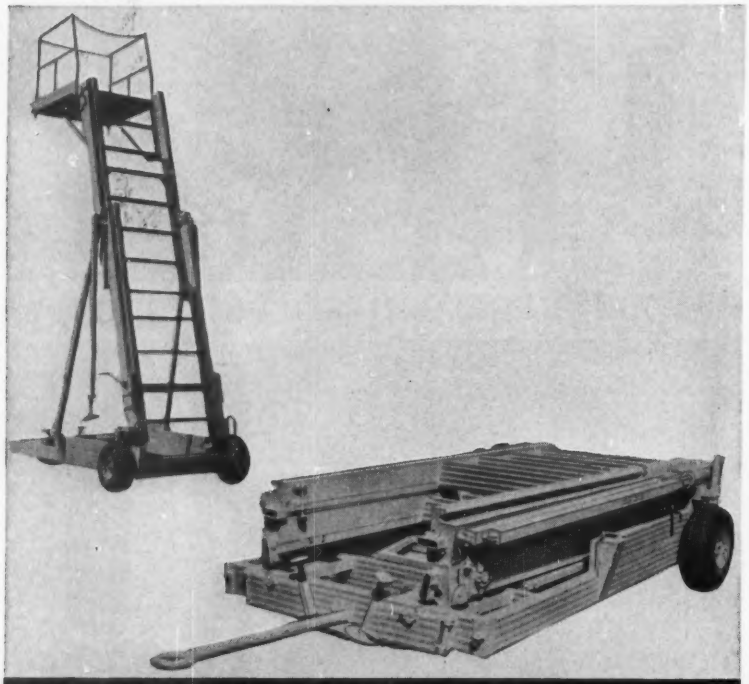
LUBRICATION REPORT

(TFE coating)



Application: *Portable Aircraft Maintenance Stand Lubrication.*

Problem: *To Minimize sliding friction at widely varying temperatures.*

Solution: *'EMRALON'® 310 (a tetrafluoroethylene pigmented, bonded film lubricant) spray-applied and baked at 300° F. for one hour.*

RESULT: *ALL-WEATHER COATING GIVES TELESCOPING STAND NEEDED LOW-FRICTION SLIDING SURFACES*

This lightweight portable aircraft maintenance stand was developed for use by the U. S. military forces by South River Metal Products Co., Inc., of South River, N. J. Approximately 40 lineal feet of telescoping surfaces are contained in the stand which elevates to 13 feet for use, and compacts to a height of only 2 feet for transporting. Tests showed that the sliding magnesium sections were readily subject to galling and seizure. The dry-film coating obtained with Acheson's 'EMRALON' 310 provides the necessary lubrication through an ambient range from desert heat to Arctic sub-zero temperatures . . . and does not cake, evaporate or freeze.

Perhaps one of Acheson's series of TFE coatings can help solve your dry-film lubricating problem. Write for 'EMRALON' 310 or 'EMRALON' 320 (air dry) Product Data Sheets. Dept. **MD-2.**

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achieve a constant angular velocity ratio of unity. Such a ratio would be desired for uniform transmission of torque using a conventional propeller shaft. It is also conceivable that such a mechanism could be used as a function generator.

ASME Paper No. 60-WA 37, "Kinematics of a General Arrangement of Two Hooke's Joints," presented at the Winter Annual Meeting, New York, Nov.-Dec., 1960, 4 pp.

hydraulic

Principles of Replaceable Absorbent Filter Cartridges

H. A. Wilson, assistant sales manager, Commercial Filters Corp.

Use of absorbent filter media on hydraulic oils in mobile equipment. In such an arrangement, the logical medium, from a standpoint of practicability, is the replaceable cartridge.

An ideal filter installation, of absorbent type, would have an element suitable for full-flow service in the pressure line following the pump. The element should provide positive retention of all abrasive particles of a size considered to be harmful in contact with mating parts. Also, it should possess: Adequate dirt-storage capacity for extensive service life; a favorable pressure drop versus flow characteristic that confines the physical volumetric size within acceptable limits; resistance to elevated temperatures; structural qualifications with respect to those areas having to do with collapsing, channeling, rupturing, and bypassing; stability in the matter of medium migration; and the inherent capacity to hold seals.

SAE Paper No. 223A, "Principles of Replaceable Absorbent Filter Cartridges," presented at the SAE National Farm, Construction, and Industrial Machinery Meeting, Milwaukee, Sept., 1960, 9 pp.

Characteristics of Hydraulic Motors

R. A. Egge, engineering section chief, Vickers Inc.

Types, performance, and applications of hydraulic motors. There are two basic types: Linear and rotary. Hydraulic cylinders are lin-

ear motors. Rotary motors are divided into two classes: Intermittent (rotary actuators), and continuous. A complete list of continuous, rotary, hydraulic motors includes: Fixed, variable, constant speed, constant power, and servo-controlled.

A hydraulic pump can be used as a motor and a hydraulic motor can be used as a pump. The motor is the more efficient of the two when used in a dual role. The pressure-compensated variable-displacement hydraulic motor is especially adept for starting and accelerating high inertial loads.

Paper, "Characteristics of the Hydraulic Motor," presented at the 10th Annual Aircraft Hydraulic Conference, Detroit, Nov., 1960, 9 pp.

Torque and Cavitation In Butterfly Valves

Turgut Sarpkaya, professor, Dept. of Engineering Mechanics, University of Nebraska

An approximate solution for the practical case of three-dimensional butterfly valves, based on the results of the more theoretical two-dimensional case. Conclusions are:

1. Bulk characteristics of flows through two-dimensional and axially symmetrical butterfly valves are essentially the same.
2. Inception of cavitation can be predicted from comparative two-dimensional studies as a function of the geometry of the valve system and of the upstream and downstream conditions.
3. Torque to be provided for varies widely for various conditions but is nevertheless perfectly definite and subject to calculations when the controlling factors are known.

ASME Paper No. 60-W-105, "Torque and Cavitation Characteristics of Butterfly Valves," presented at the Winter Annual Meeting, New York, Nov.-Dec., 1960, 8 pp.

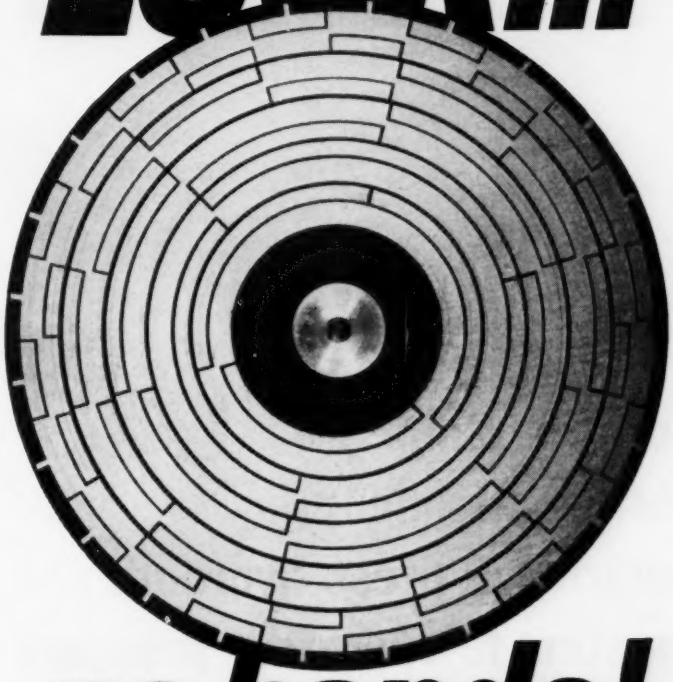
processes

Practical Implications Of the Plasma Torch

James A. Browning and George A. Klasson, Thermal Dynamics Corp.

The plasma arc cutting process and its applications. Electric-arc

LOOK...



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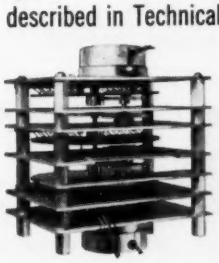
This printed circuit disc is the "face" of a clock that tells time in digital code

...or any code your computer, control system, or data processing device needs to keep it properly in touch with the world of real time.—A. W. Haydon is a company of infinite variation when it comes to such analog-to-digital converters, or "binary encoders". Time periods range from seconds to weeks. Sizes range from miniature to large. They come sealed, enclosed or open, with AC, DC, or pulse drive, and with an imposing variety of accessory equipment.—The model shown is for commerical use. It provides a discrete signal for each two-minute interval over a 28-day period. It is used, among other places, in an automatic parking lot ticket computing system.—This and several other time code generators are described in Technical Brochure SP9-2. It's yours for the asking. Similar solid-state devices can be supplied by our Culver City, Calif., facility.



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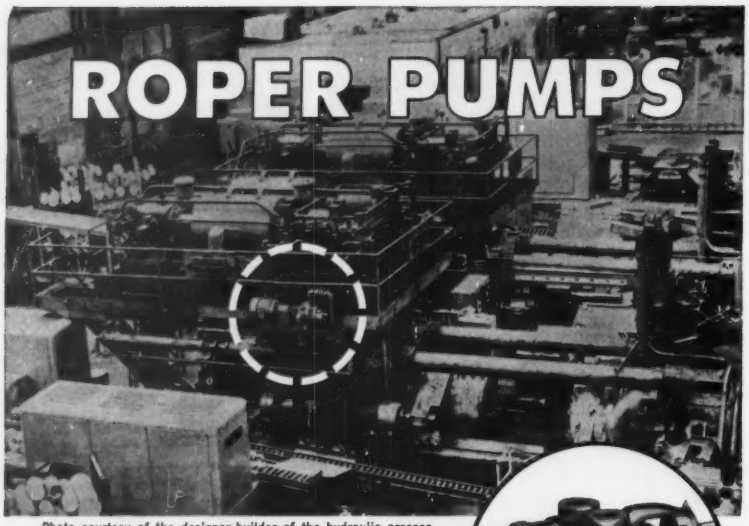
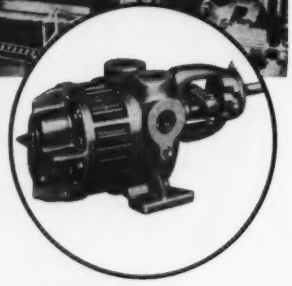


Photo courtesy of the designer-builder of the hydraulic presses



SERIES F Model 2F75 Spec. 35

pre-fill pump brings aluminum extrusion press hydraulic system to operating pressure

1-300 GPM CAPACITIES • OPERATING PRESSURES TO 300 PSI

The hydraulic system of this self-contained oil hydraulic four column aluminum extrusion press, designed and built by Birdsboro Corporation, relies on a Roper Series F pre-fill pump to fill the hydraulic cylinder with oil to operating pressure. The Roper pump was installed as original equipment when the press went into operation five years ago. The 200 SSU viscosity oil is pumped at the rate of 84 gpm and pressure of 125 psi as pump operates at 1140 rpm. Series F pumps are specially designed for transfer of clean liquids in applications such as hydraulic power pressure lubrication or fuel oil transfer. Pump has arrangement for circulation of oil through bearings to control their operating temperature.

INSIDE STORY OF SERIES F

- **PUMPING GEARS:** pair of six-toothed helical gears of heat-treated steel, accurately finished to keep pump running smoothly, quietly.
- **BEARINGS:** two bronze, flange-type bearings on each side give ample support to pumping elements which are self-cooled and lubricated by liquid being pumped.
- **BACKPLATE:** carries pipe connections, designed to permit removal of internal parts without disturbing piping or drive.

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heating of a gas produces temperatures an order of magnitude greater than those associated with chemical reactions. Such heating is commonly termed electrothermal, or plasma, heating. To produce a high-velocity jet, arc heating is provided at elevated pressure within a confined volume. The heated gas expands to lower pressure through a nozzle, and velocities measured in tens of thousands of feet per second can be achieved.

Electrothermal jets are presently receiving great attention for such applications as space propulsion at high specific impulse. In addition, plasma is finding rapid acceptance in many industrial fields. In particular, the use of such equipment for the cutting of metals offers tremendous advantages over present techniques.

ASME Paper No. 60-WA-242, *"Practical Implications of the Plasma Torch," presented at the Winter Annual Meeting, New York, Nov.-Dec.,* 1960, 7 *pp.*

techniques

Mechanical Measurements In Computer Systems

A. J. Fuimarello, International Business Machines Corp., Poughkeepsie, N. Y.

Three techniques for measuring tape tension, reel hub pressure, and printing impact forces. The transducers are described, and the theoretical considerations which led to their design are discussed. In addition, the dynamic-response characteristics for these transducers are given.

Mechanical measurements of the type described in this report can be applied to almost any mechanism.

AIEE Paper No. CP 60-967, *"Dynamic Mechanical Measurements in Computer Systems," presented at the AIEE-AIChE-IRE-ISA-ASME Joint Automatic Control Conference, Cambridge, Mass., September,* 1960, 8 *pp.*

Analog Solution of Some Functional Analysis Problems

K. K. Graupe, Boeing Airplane Co., Seattle, Wash.

Several methods of setting up an analog computer to solve a system of coupled equations for several un-

known functions. Among four demonstrated computation methods, the least-magnitude method should be preferred, in general, because of its relative simplicity. Nonlinear problems can be solved. However, it may be necessary to feed additional information into the computer which selects the desired one of several possible solutions.

Two computation methods—least-squares and least-magnitude—can digest and weigh redundant data, thereby improving the accuracy of the computer. Without using especially quick computer components, a response time of 0.1 sec is obtained. Thus, the computing methods shown in this report should be able to find "momentary" quantities continuously while a process is running. It is estimated that the use of redundant data also will decrease the response time of the computer.

These methods can solve ordinary differential equations. Then it is not necessary to isolate the highest derivative.

AIEE Paper No. 60-1230, "The Analog Solution of Some Functional Analysis Problems," presented at the AIEE Fall General Meeting, Chicago, Ill., October, 1960, 7 pp.

Modular Design Of Hydraulic Presses

Walter Ernst, vice president and director of engineering, The Commonwealth Engineering Co. of Ohio

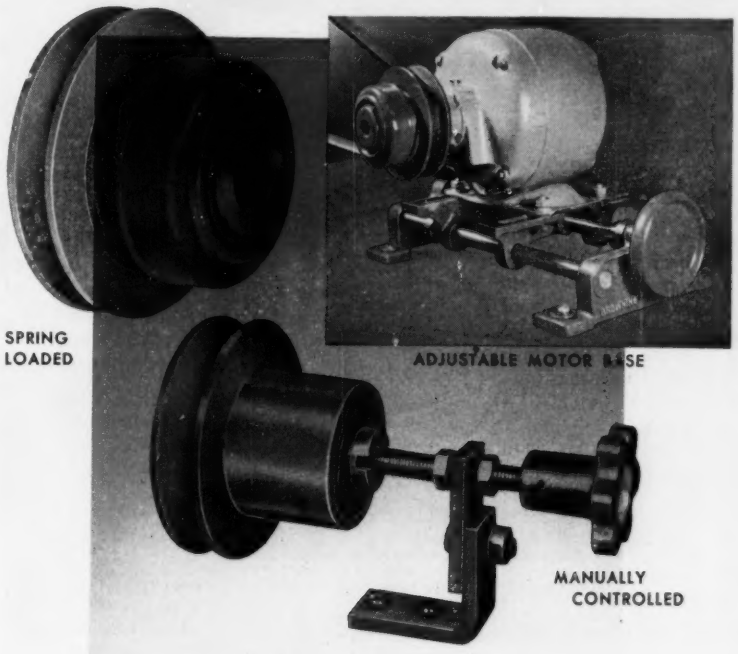
Standardization of sizes and capacities, and utilization of common components in a line of hydraulic metal-working presses. The program comprised both type and size standardization. A basic, single-acting press of standardized design is the nucleus of all versions.

One optional modification was provided in the basic cylinder-ram assembly to suit particular press operations. Some press operations require a relatively short power stroke at relatively high pressure. On other operations, a relatively long stroke is required at relatively low pressure, followed by a relatively short stroke at high pressure. Either of these arrangements may be supplied when the press is built, or changed at a later date without affecting the design of the press.

The standardization program

Browning

VARIABLE SPEED DRIVES



Now you can get famed Browning quality in *motion controlled* variable speed drives. Serving ⅛ to 2 hp requirements, this new Browning line includes:

- **Spring loaded** variable pitch sheaves; 3″, 4″, 5″ and 6″ OD
- **Manually controlled** variable pitch sheaves in same sizes
- **Adjustable motor base,** for quick accurate adjustment of center distance

Browning's spring loaded sheave replaces any ordinary sheave, driver or driven, to provide a wide speed range simply by adjusting center distance. In combination with the new manually controlled type, twice the normal range is attained with no change in center distance and without misalignment. The convenient bracket knob permits infinite speed control. Both sheaves use oil impregnated bushings that are lubrication-free, always clean, always low in maintenance.

Browning variable speed drives help you achieve maximum production from your equipment. Your Browning distributor can give you complete details. Ask for Catalog SL-101. **Browning Manufacturing Company, Maysville, Kentucky.**

Browning... OUR 75th YEAR

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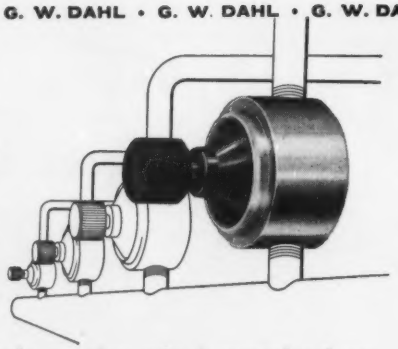

Dahl FLEXI-PHRAGM packless diaphragm valve ideal for instrument air and other gas and liquid services . . . for isolating and/or testing the pneumatic circuit in process control loops.

Resilient diaphragms (Neoprene, Viton A or Buna) withstand deformation by slurries, trapped impurities (unfiltered service) . . . still provide positive shut-off. Diaphragms resume original configuration when valve is opened and particles washed away . . . even after prolonged closures.

Rated to 500 psig and 180°F. Closing torque only 10 lb.-in. (as rated) in dead end service. Brass bodies with ⅛" or ¼" NPT connections. Panel mounts available.

REQUEST complete data on this low cost, high performance valve. G. W. Dahl Co., Inc., 83 Tupelo St., Bristol, R. I.

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Circle 494 on Page 19

HOBBS HOUR METERS

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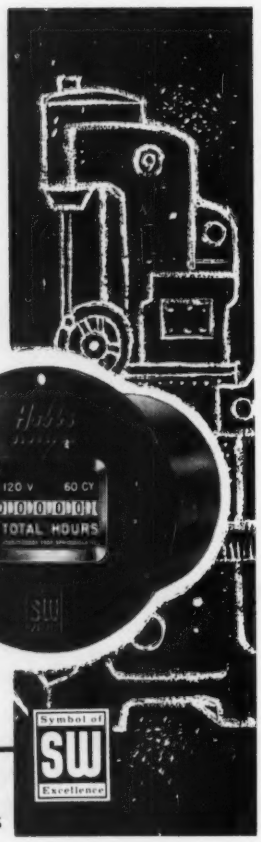

Hobbs Industrial Hour Meters provide continuous supervision of the running time of industrial machines . . . eliminating errors and deficiencies for maximum production. These elapsed time indicators tell when servicing is due . . . indicate the costs of running hour for both the machine and occupied space.

Hobbs Industrial Hour Meters make it easy to determine the life and repair costs per running hour of industrial machines . . . the actual running time of leased equipment and equipment to be sold. They set up a sound basis for service contracts. For complete information . . .

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A DIVISION OF STEWART-WARNER CORPORATION

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Circle 495 on Page 19

provides four tonnage and speed options, six bed sizes, eight daylight-stroke options, and three cushion options—a total of 576 different models.

NCIH paper, "The Standardization and Module Construction of a Line of Hydraulic Presses," presented at the 16th Annual National Conference on Industrial Hydraulics, Chicago, Oct., 1960, 8 pp.

A New Function Generator

C. W. Eggers and T. W. Sze, University of Pittsburgh

A new type of function generator which employs the combined design techniques of digital circuits and analog computing circuits. The primary purpose of the function generator is to provide an approximation to a specified function as a forcing function to an actual or a simulated system. Aside from this primary application, flexibility and low cost make the new generator particularly well-suited to the following applications:

1. For computer study of transient response of systems, the generator can provide an arbitrary but known forcing function other than a step function or a ramp function.
2. As a laboratory instrument, the new generator may be used for a number of standard functions which normally require a separate instrument for each function.
3. If the integrator of the generator is by-passed, the generator becomes suited for the studies of discrete signal systems.
4. If two function generators are available, they may be designed to allow for an adjustable delay between their time scales.

AIEE Paper No. 60-1203, "A New Function Generator," presented at the AIEE Fall General Meeting, Chicago, Ill., October, 1960, 9 pp.

Data-Handling Efficiency Of a Digital Computer

Herbert Freeman, Sperry Gyroscope Co., Great Neck, N. Y.

Development of an efficient program for a digital computer used in a control system. The efficiency of a program is a measure of the effectiveness with which the program enables a computer of minimum capability to meet the require-

ments of the system. Computer capability is measured in terms of speed and word length. For a given system, the less capable the computer, the more severe the requirements for an efficient program. The concept of the information-handling efficiency of a program is utilized as a program figure of merit. It provides a basis for the quantitative comparison of quality among different programs.

AIEE Paper No. 60-970, "On the Information-Handling Efficiency of a Digital Computer Program," presented at the AIEE-AIChE-IRE-ISA-ASME Joint Automatic Control Conference, Cambridge, Mass., September, 1960, 7 pp.

lubrication

Metal Contact and Friction Between Sliding Surfaces

M. J. Furey, Esso Research and Engineering Co.

Description and use of a new device developed to measure and continuously record both the extent of metallic contact and friction between sliding metal surfaces. This device is particularly useful in studying:

1. Transition from a condition of no metallic contact (hydrodynamic lubrication) to one of continuous metallic contact ("boundary" lubrication).
2. Time history of metallic contact and friction phenomena.
3. Action of antiwear and "extreme pressure" additives.

In a study reported in this paper, load was varied from 13,700 to 141,000 psi mean Hertz pressure. Speed was varied from 60 to 3000 rpm.

It was found that appreciable metallic contact of an intermittent nature can occur under reasonably light loads. In addition, metallic contact was indicated to be more prevalent than might be expected from other published data.

Time, load, speed, mineral oil viscosity, and additive type were found to be important variables influencing metallic contact and friction. With straight mineral oils, the influence of operating time on metallic contact appears to be due to a polishing effect from wear. The effects of load, speed, and viscosity are probably due to changes

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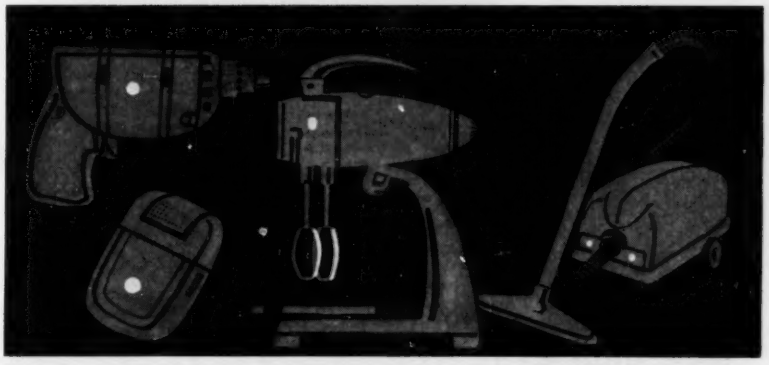

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Circle 496 on Page 19

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New Char-Lynn Hydraulic ORBIT MOTORS® deliver Full Torque regardless of speed range

Even under normally critical conditions involving low RPM, Char-Lynn ORBIT MOTORS maintain maximum efficiency . . . and because these ORBIT MOTORS function as both a fluid displacement motor and gear reducer, no speed reduction devices are required.

Char-Lynn ORBIT MOTORS make possible unlimited hydraulic design opportunities for constant and variable speed drives, hydrostatic transmissions and remote controls.

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- Pressures to 2000 PSI
- Torques to 3000 lb. in.

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in the thickness of the oil film.

Surface damage was found to be more closely related to metallic contact than to friction. The effects of additives on metallic contact were much more pronounced than their effects on friction.

ASLE Paper No. 60 LC-10, *"Metallic Contact and Friction Between Sliding Surfaces," presented at the ASLE/ASME Lubrication Conference, Boston, Oct.,* 1960, 8 *pp.*

electrical

Magneto-Thermionic Power Generation

A. Schock, Republic Aviation Corp., Farmingdale, L. I., N. Y.

The concept of using thermionic emission for converting heat to electricity without moving parts.

Analysis indicates that:

1. The high currents present in thermionic generators induce magnetic fields which deflect the emitted electrons.
2. Even modest field strengths force a large fraction of the current to return to the emitter.

AIEE Paper No. CP 60-1033, *"Magneto-Thermionic Power Generation," presented at the AIEE Pacific General Meeting, San Diego, Calif., August,* 1960, 6 *pp.*

TO OBTAIN COPIES of papers or articles abstracted here, write directly to:

AIEE—American Institute of Electrical Engineers, 33 West 39th St., New York 18, N. Y., papers 50 cents to members, one dollar to nonmembers.

ASLE—American Society of Lubrication Engineers, 5 North Wabash Ave., Chicago 2, Ill.; papers 50 cents to members, 75 cents to nonmembers.

ASME—American Society of Mechanical Engineers, 29 West 39th St., New York 18, N. Y., papers 50 cents to members, one dollar to nonmembers.

NCIH—National Conference on Industrial Hydraulics, sponsored by Illinois Institute of Technology, 3300 South Federal St., Chicago 16, Ill., Vol. XIV, Conference Proceedings, 6 dollars each.

SAE—Society of Automotive Engineers, 485 Lexington Ave., New York 17, N. Y.; papers 50 cents to members, 75 cents to nonmembers.

SPE—Society of Plastics Engineers, Inc., 65 Prospect St., Stamford, Conn., papers 25 cents to members, 40 cents to nonmembers.

Tenth Annual Aircraft Hydraulics Conference, sponsored by Aero Hydraulics Div., Vickers Inc., Detroit 32, Mich.

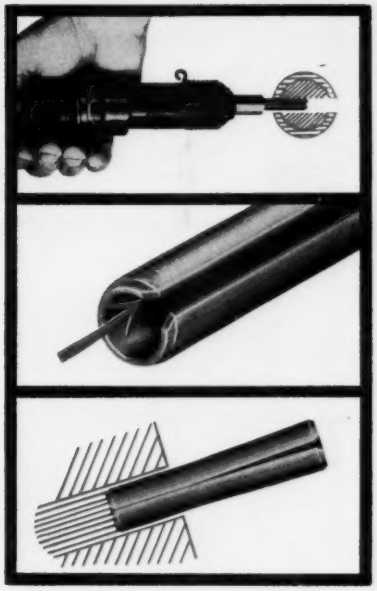
Circle 497 on Page 19

Rollpin won't mushroom or telescope

There are no installation or removal problems with Rollpins. Because of their column strength they can be readily driven with a hammer, removed with a punch without bending or collapsing. Of course production line tooling such as an arbor press, a pneumatic hammer . . . even a hand riveter . . . is ideal for Rollpin insertion.

Rollpin won't damage or enlarge hole

With smoothly chamfered ends providing an easy lead-in, Rollpin is compressed into complete conformity with the shape of the hole. The exclusive, v-shaped, coped corner design eliminates possibility of damage to the hole walls. They prevent any possible scoring action as the pin is driven and insures uniform insertion and removal characteristics. The benefit to you: the same pin can be reused in the same hole.



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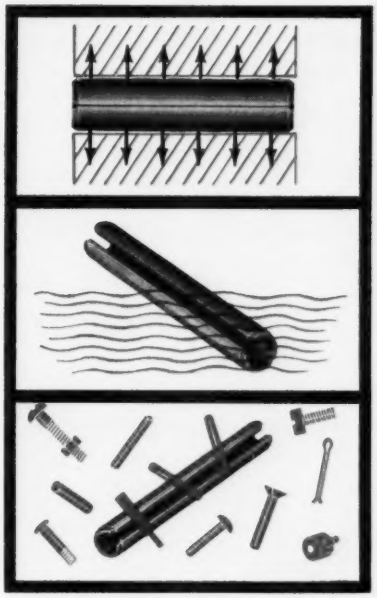
Rollpin exerts EVEN pressure

In some fasteners, only a portion of the fastener shaft does the actual holding. Rollpin, however, exerts a uniform pressure around the entire inside surface of the hole—giving you maximum holding power and superior resistance to vibration.

Split tubular construction assures uniformity of heat treatment that is difficult to obtain with spiral types of pins; there is an even plating "throw" inside the pin as well as outside for superior corrosion protection.

ONE TYPE of Rollpin does EVERY TYPE of job

Versatile Rollpins will replace at least 12 different types of fasteners. Every Rollpin can be hopper-fed, can be installed with a single operation. They are available, from stock, in a wide range of lengths and in diameters from 1/16" to 1/2". Manufactured from carbon or corrosion resistant steels and beryllium copper.



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Helpful Literature
for Design Engineers

For copies of any literature listed, circle Item Number on Yellow Card—page 19

Turbine Flowmeter

Propeller-type flowmeter that transduces gas velocity to a millivolt signal, frequency of which is proportional to flow rate, is described in Specification Bulletin 10C1505-2. Full details on the material of construction, mounting, performance, output, and repeatability are given, using curves, tables, text, and line drawings. 4 pages. Fischer & Porter Co., 739 Jacksonville Rd., Warminster, Pa.

Circle 701 on Page 19

Pressure Vessels

Bulletin 140 describes Hystran filament-wound reinforced plastic as applied to the manufacture of high-pressure storage vessels. Design and application data curves permit the engineer to design a pressure vessel, including estimating size, determining wall thickness, and final calculation of weight and size. Also included are detailed descriptions of five typical pressure vessels and a comparison of basic characteristics of Hystran, aluminum, titanium, and steel. 6 pages. Lamtex Industries Inc., Motor Avenue, Farmingdale, N. Y.

Circle 702 on Page 19

High-Temperature Insulation

New brochure describes and illustrates six high-temperature products: Flexite Teflon extruded tubing; Flexlead Teflon-insulated lead wire and cable; Hygrade H silicone-rubber-coated glass-fiber sleeving; Flexite SR extruded tubing; Flexlead silicone-rubber-insulated lead wire and cable; Flexite silicone-rubber triangular guideline tape. Each product is presented with applications, features, and data on temperature ranges. 4 pages. L. Frank Markel & Sons, Norristown, Pa.

Circle 703 on Page 19

Waveguide Chart

Chart TL-605 is designed to assist the specifying engineer in selecting flexible rectangular waveguides for specific applications. It incorporates such details as frequency, construction, materials, dimensions, bend radii, jacket, and pressure requirements. Arrangement of the details enables selection of the proper device for individual requirements with a minimum of effort. Technicraft Div., Electronic Specialty Co., 116 Waterbury Rd., Thomaston, Conn.

Circle 704 on Page 19

Refractory-Metals Calculator

Tungsten - molybdenum calculator to compute weight and sizes of these refractory metals is now available. Calculator has conversion tables for wire and rod. It also can be used as a slide calculator for rounds, squares, tubes, sheet ribbon, and flat bar. Standard density figures for tungsten and molybdenum in the wire and rod conversion tables are used. Calculator includes a decimal-equivalent table for convenience. General Electric Co., Dept. LMC-1, Nela Park, Cleveland 12, Ohio.

Circle 705 on Page 19

Ball Bearings

Form 480, covering wide inner-ring ball bearings and power-transmission units, contains complete specification charts, diagrams, and photographs. Pillow blocks, flange cartridges, cylindrical cartridges, and take-up units are also included. 60 pages. Fafnir Bearing Co., 37 Booth St., New Britain, Conn.

Circle 706 on Page 19

Delrin Acetal Resin

Booklet A-18404 contains up-to-date tables and discussions on Delrin and its properties, design considerations, forming techniques, and examples of its application in a variety of products and industries. Booklet incorporates many charts, graphs, tables, and photographs. 24 pages. E. I. du Pont de Nemours & Co., Wilmington 98, Del.

Circle 707 on Page 19

Wire Markers

Bulletin 130-G contains a list of over 400 different Perma-Code miniature wire markers for permanent or temporary identification of small wires and electronic components. It also contains complete, up-to-date application information and specifications for four sizes of wire markers. Technical and engineering data are set up for fast reference. 8 pages. W. H. Brady Co., Dept. 130, 727 W. Glendale Ave., Milwaukee 9, Wis.

Circle 708 on Page 19

Gear Motors

Fractional-horsepower units are pictured in colorful bulletin. Specifications are given, and examples of applications for the various motors are provided. 4 pages. von Weise Gear Co., 9353 Watson Industrial Park, St. Louis 26, Mo.

Circle 709 on Page 19

Self-Locking Fasteners

Aerospace Catalog 960 is a design manual which focuses attention on reduced-dimension, lightweight types of self-locking fasteners. It provides the design engineer with a concentrated package of nut shapes useful in the assembly of units intended for avionic and electronic applications. Special emphasis is placed on clinch nuts, including information on installation. Many line drawings and photographs are included. 64 pages. Elastic Stop Nut Corp. of America, 2330 Vauxhall Rd., Union, N. J.

Circle 710 on Page 19

Chain, Sprockets, Couplings

Catalog 760 on stock roller chain, sprockets, and couplings, carries new ARSCM horsepower ratings which permit the use of roller chain in a broader range of applications, because of the greater loads which can be transmitted at higher speeds. Full information on stock roller chain and sprockets, top-plate conveyor chain, heavy-duty roller chain, Micropitch miniature roller chain, and flexible couplings is provided. 118 pages. Diamond Chain Co. Inc., 402 Kentucky Ave., Indianapolis 7, Ind.

Circle 711 on Page 19

Steel Specification Chart

New chart, Sec. D, No. 1, permits easy identification of alloy-steel government specifications. Chart shows chemical analysis requirements for widely used Military, AN, and Federal alloy-steel specifications. Also listed are specified forms (sheets, bars, and tubing) and nearest corresponding SAE, AISI, and AMS numbers. Chart is printed on durable card stock, 8½ x 11 in., tabbed for ready reference. Peter A. Frasse & Co. Inc., 17 Grand St., New York 13, N. Y.

Circle 712 on Page 19

Servo Motors

Short-form catalog includes complete specification data on 60 and 400-cycle servo motors. Inertial-damped servo motors and servo motor-tachometers are also included. Photographs and tables are used to provide complete specifications. 20 pages. Eastern Div., IMC Magnetics Corp., 570 Main St., Westbury, L. I., N. Y.

Circle 713 on Page 19

Fasteners

Data on lock nuts, clinch nuts, weld nuts, special units, and semi-finished nuts are provided in Catalog 161. Various units are pictured, advantages are pointed out, and all specifications are given. Application data are given for some of the nuts. 20 pages. Grip Nut Co., South Whitley, Ind.

Circle 714 on Page 19

Tulip bed for stainless...

In our Viaduct Plant shear bay this "tulip bed for stainless" is important to you. It is this ball-bearing bed that helps our shearmen position plate easily, quickly, efficiently. But there's more than speed shown here. Carlson engineers modified this modern shear to provide unusually accurate cutting of stainless plate to your specifications.

Equipment of this type, coupled with our thorough knowledge of stainless steel, brings you the finest products . . . the finest service. For almost a quarter of a century it has been our aim to serve you best by producing what you want and delivering it on time.

Circle 499 on Page 19

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- Less than 10 seconds installation—merely insert grommet into material to be fastened and insert plunger in grommet.
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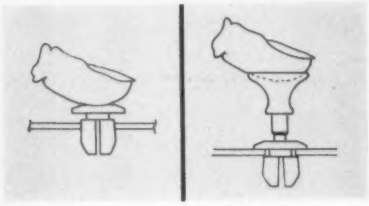
- Nylatch allows up to .040 misalignment tolerance.
- Rugged two-piece construction gives 30,000 complete cycles of operation. Thoroughly tested for temperature, creep characteristics, fatigue and load.
- Versatility of design allows you a selection of plunger head designs. Available in wide range of decorator colors.



Press grommet into removable sheet — Press plunger into installed grommet

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Circle 500 on Page 19

HELPFUL LITERATURE

Silicone Rubber Selection

Revised silicone rubber Selector Chart, CDS-145C, contains comprehensive data on applications, typical properties, primary classes, and standard industry and military specifications. To make selection of the proper silicone elastomer easy, compounds are divided into four general classes and typical uses of each class are described. Chart is printed in four colors on heavy stock. 4 pages. Silicone Products Dept., General Electric Co., Waterford, N. Y.

Circle 715 on Page 19

Tool-Steel Identifier

Easy-to-use tool-steel identifier, in the form of a compact slide rule, provides a complete listing of over 600 brand names of tool steel. Brand name, producer, AISI number, and manufacturer's equivalent brand are revealed at a glance through windows located on both sides. Complete AISI tool-steel classification table is shown on the reverse side of the identifier, including all chemical compositions. Universal-Cyclops Steel Corp., Bridgeville, Pa.

Circle 716 on Page 19

Vibration Mounts

Design and construction features of Rexon vibration mounts are fully described, diagrammed, and illustrated in revised bulletin. Engineering details, performance data, and installation information are given. Brochure includes simple tables and instructions which enable anyone to compute the size and type of mounts required to support in shear the load of a given installation. 8 pages. Rexon Mount Div., Hamilton Kent Mfg. Co., 427 W. Grant St., Kent, Ohio.

Circle 717 on Page 19

Control Transformers

Catalog 141-B01 concisely describes the functions of machine-tool control transformers and gives suggestions for determining the proper transformer for the application. Catalog shows individual regulation curves for nine standard rating transformers. Used as a guide, suggestions in the catalog can avoid the use of an over or under-rated transformer. 4 pages. Acme Electric Corp., 111 Water St., Cuba, N. Y.

Circle 718 on Page 19

Valve Sizing Charts

Sizing Chart Bulletin JSC-1 shows how to size the company's sliding gate regulators and control valves. Simplified charts cover steam, liquid, and gas service, and cross-reference method of compiling information makes sizing easy by eliminating the need for rulers, formulas, or slide rules. Technical data, applying to all makes of valves, tell how to adjust sizing for variations in pressure, temperature, viscosity, or specific gravity. 4 pages. OPW-Jordan, 6013 Wiehe Rd., Cincinnati 13, Ohio.

Circle 719 on Page 19

Pressure: to 540 psi.

Ten orifice sizes: 3/64" through 1/4".

Wide voltage range: standard with 115V. AC.; also 12, 24, 208, 230, 460V. AC. 50/60 cycle.

Body: brass bar stock or 18-8 stainless steel. All moving parts, stainless. Seat disc, synthetic rubber. Sizes, 1/8" and 1/4" NPT. Both conduit and grommet types.

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Yes, "Master-mite" is the mighty mite of solenoid valves. Useable on a wide range of media including hydrogen, acetylene, etc. Works right in any position. Small, but with extra strength in the Marsh manner. Coils never overheat. Leak tight. Remarkably quiet.

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VALVES

Circle 501 on Page 19

What are your V-Belt needs? DURKEE-ATWOOD solves them!

When you buy V-Belts, you want full-rated power transmission, consistent performance and long, trouble-free life. Power drive problems vary from industry to industry and machine to machine, whether OEM or replacement. Durkee-Atwood can meet any of your V-Belt needs with the right belt, a belt made with the newest high tenacity fibres, carefully engineered and thoroughly tested for performance. For any of your V-Belt needs, or for drive design assistance, contact your nearest Durkee-Atwood distributor or factory representative. Or write direct to Industrial Division, Durkee-Atwood Company, Minneapolis 13, Minn.

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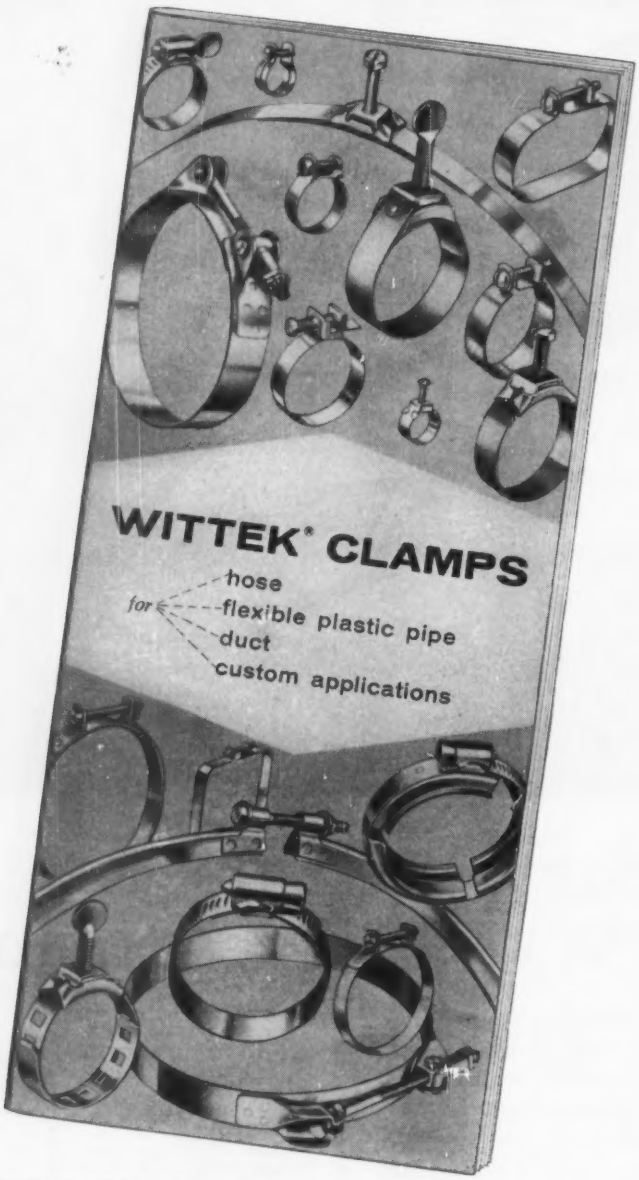
DURKEE-ATWOOD V-BELTS

DURKEE-ATWOOD COMPANY MINNEAPOLIS 13, MINNESOTA

WHAT'S YOUR CLAMPING PROBLEM?



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Whatever your clamping problem, it's a safe bet that Wittek has the exact type and size clamp to do the job. Write for this new 16-page brochure on standard Wittek clamps and custom-made clamps.

Quality Clamps for Over 35 Years

WITTEK Manufacturing Co.
4349 West 24th Place, Chicago 23, Illinois

CLAMPS for Every Application

Circle 503 on Page 19

HELPFUL LITERATURE

Hydraulic Power Units

Bulletin 0980-B1 completely catalogs 37 new hydraulic power units. All pertinent application information is included concerning twelve 1000 and 2000-psi single-pump models, 15 double-pump models of similar working capacities, and 10 continuous-booster models with automatic pressure intensification to 5000 psi. Table relating gpm delivery to horsepower input is included. 6 pages. Hannifin Co., Dept. 116, 501 S. Wolf Rd., Des Plaines, Ill.

Circle 720 on Page 19

Roll-Formed Shapes

Bulletin 760 shows roll-formed shapes in actual size. Bulletin describes the techniques used in roll-forming shapes from aluminum, brass, copper, zinc, titanium, galvanized, stainless, and carbon steels, painted, clad, and vinyl-coated metals. It shows various vinyl and embossed decorative finishes available, and gives examples of how punching and notching operations can be combined with roll forming. Dimensional drawings illustrate line of standard angles, angles with weld projections, standard channels, square and round lockseam tubing, and round butted tubing. 36 pages. Roll Formed Products Co., Oakwood Avenue, Youngstown, Ohio.

Circle 721 on Page 19

Worm-Gear Screw Jacks

Engineering and selection data for 2 to 15-ton worm-gear screw jacks are provided in Bulletin 442IJ. Included are speed and loading data, torque-horsepower requirements, and selection notes on estimating horsepower requirements, torque input for a system, and operation. 4 pages. Joyce-Cridland Co., 2027 E. First St., Dayton 3, Ohio.

Circle 722 on Page 19

Sponge Iron Powders

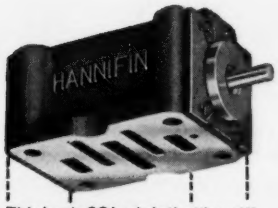
Form 110 is titled "From Sponge Iron Powders to Powdered Metal Parts." Topics covered include a definition of powder metallurgy, explanation of iron powder, the iron-powder manufacturing process, and properties of iron powders. Also included are a fabrication flow chart, information on pressing and sintering, section on designing for powder-metal parts, and on the economies of powder metallurgy. Size range of powder-metal parts is defined, as well as special and outstanding physical properties. 12 pages. Hoeganaes Sponge Iron Corp., Riverton, N. J.

Circle 723 on Page 19

Timing Motors and Controls

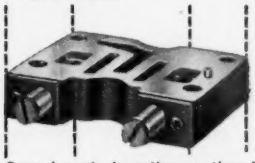
Condensed illustrated catalog on timing motors and time and torque controls demonstrates the variety of motors and controls available. Dimensions and special design characteristics of the compact electric timing units are included. 8 pages. Haydon Div., General Time Corp., 245 E. Elm St., Torrington, Conn.

Circle 724 on Page 19



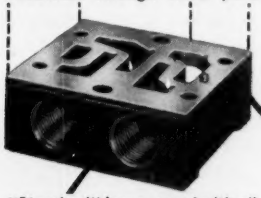
This basic CC body is the "heart" of every CC valve. Its one moving part is the "spool poppet", a Hannifin exclusive that seals bubble tight at either end of its short stroke. Note the ample air passages—all ¼" IPS or larger. This is single-actuator, spring return version.

This is the same body with double-end "spool poppet"—used when two actuators are required.

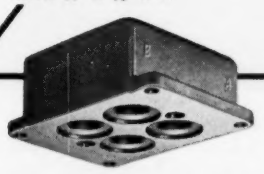


Speed control section, optional—designed to restrict exhaust flow, only, through either or both cylinder ports. Flow to the cylinder remains completely unrestricted through either port.

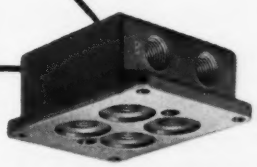
For foot-operated valves, the actuator is also the base, and this rear-ported adapter is used. Available tapped either ¼" or ⅜" IPS.



"Standard" base—used with all but foot-operated models. Every CC base is available tapped either ¼" or ⅜" IPS.



Optional base for "O" ring gasket mounting. Supplied complete with 4 O-rings.



"Universal" base, tapped from beneath and from both sides. Four pipe plugs supplied. Can also be used with O-rings.

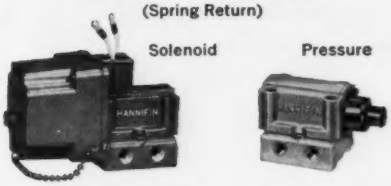
THESE QUICK-RESPONSE 4-WAY VALVES MOVE AIR DOWN THE LINE—FAST!

Hannifin CC valve design is the reason. Short, positive strokes of the "spool poppet" open up instant and ample passages for air.

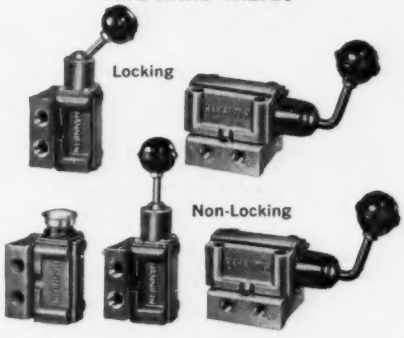
Actuation? Any way you want it!

One basic body with a wide selection of operating heads and bases—all with or without our new speed control section—give you over 3,000 choices. We can help you make the right choice . . . through our field engineering service. Call your nearest Parker-Hannifin office or write us direct for full information.

SINGLE ACTUATORS
(Spring Return)



FIVE HAND VALVES



TWO FOOT VALVES

TYPICAL COMBINATIONS
(Hundreds Available)

FOOT-OPERATED, LOCKING; PRESSURE OVER-RIDE —used on foundry machinery

CAM-OPERATED; PRESSURE-RETURN —used on automatic wash tanks

DOUBLE SOLENOID —used everywhere

PRESSURE-OPERATED; PRESSURE-RETURN —used everywhere

PARKER HANNIFIN CORPORATION

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A DIVISION
515 South Wolf Road • Des Plaines, Illinois
PNEUMATIC AND HYDRAULIC SYSTEM COMPONENTS
EUROPEAN DIVISION • PARKER-HANNIFIN N.V. • SCHIPHOL • THE NETHERLANDS

3138 PH.

Circle 504 on Page 19

ONE SECOND SENSITIVITY

to exactly set and check angles

MICROPTIC PRECISION CLINOMETER

Highly sensitive yet easily handled, the Microptic Precision Clinometer is designed for all calibration and machine setting purposes requiring the highest accuracy.

Angles through 360° are measured by referring the instrument base to the true horizontal — the inclination is read directly from the circle scale through a reading microscope. The eyepiece can be rotated to face in any direction. Interchangeable units permit daylight or artificial illumination of the reading system.

The Precision Clinometer is invaluable in setting inclinable tables for jig borers, and angular work on grinding and lapping machines; for checking angular faces and locations on jigs, fixtures and gages.

...New

Accessories—for use in horizontal position; to measure angular displacement of small parts; to comply with military environmental specifications for field use.

ENGIS
EQUIPMENT COMPANY
DIVISION OF ENGINEERING AND SCIENTIFIC INSTRUMENTATION
431 SOUTH DEARBORN ST.
CHICAGO 5, ILL.

Circle 505 on Page 19

HELPFUL LITERATURE

Bolt Selection

Bolts for the aerospace industries are discussed in new selection guide. Guide consists of a rapid identification review of some 120 different aerospace bolts. Included are tension and shear bolts, engine bolting, titanium and specialty fasteners—AN, MS, NAS, and SPS standards. Thumbnail specification sketches, each keyed to a silhouette sketch, quickly pinpoint basic information. Included are numerical designation, fastener type, material, tensile strength or other strength rating, temperature range, companion nut, if any, and point of manufacture. 24 pages. Standard Pressed Steel Co., Box 102, Jenkintown, Pa.

Circle 725 on Page 19

Photocopy Products

Form TPC-1 describes in considerable detail 33 industrial photocopy products. Printed in two colors, brochure divides the silver-sensitized photocopy line into three basic groups—slow contact, standard contact, and projection speed papers and cloths. In addition to product descriptions, three charts give suggested uses for the various materials. Information as to sample packages available is also included. 4 pages. Peerless Photo Products Inc., Shoreham, L. I., N. Y.

Circle 726 on Page 19

Electric Motors

Bulletin 2651 outlines an extensive line of electric motors to meet a broad field of application requirements. It features 23 types of motors with photographs, brief descriptions on application uses, and available ratings, enclosures, and modifications. Standard and specialized units are included. 8 pages. Louis Allis Co., 427 E. Stewart St., Milwaukee 1, Wis.

Circle 727 on Page 19

Rotary Joints

Illustrated and fully described in Catalog 310B are rotary joints that require no lubrication, work equally well for single-flow or syphon steam service, and handle steam and virtually any fluid ranging from chilled water to 600-F oil. Cut-away photographs, tables, and line drawings illustrate the design features. Detailed recommendations are also included on the proper installation of the units. 4 pages. Barco Mfg. Co., Dept. RJ-24, 500 Hough St., Barrington, Ill.

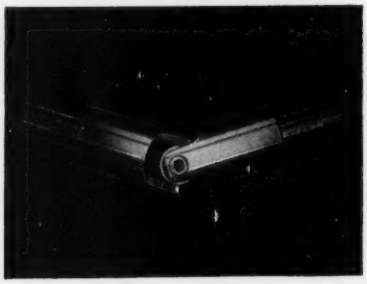
Circle 728 on Page 19

Plastics Molding

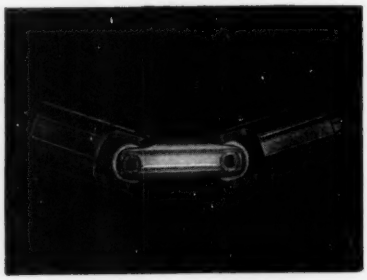
Six basic techniques used to mold thousands of products are explained in a letter-sized booklet. Each molding technique is described, and specific advantages and applications are listed. Also given are physical and chemical properties of parts molded by each method. 10 pages. Reinforced Plastics Div., Society of the Plastics Industry Inc., 250 Park Ave., New York 17, N. Y.

Circle 729 on Page 19

How Curtis helped a design engineer "BEAT THE HEAT"



This single universal joint in a ribbon-stripping machine was operated at a 34° angle. The joint heated up, wear was excessive. (Curtis Joints have been tested at angles up to 37°, but we do not ordinarily recommend angles greater than 30°.)



Curtis engineers recommended a *double* Curtis joint, which reduced the angle to 17° per joint. Result: no overheating, improved efficiency, longer life.

You can depend on Curtis engineering in any problem of angular power transmission. And you can depend on

CURTIS UNIVERSAL JOINTS

because our catalog torque and load ratings are substantiated by constant tests under production conditions.

14 SIZES ALWAYS IN STOCK — 3/8" to 4" O.D. (6" joints on special order)

Not sold through distributors. Write direct for free engineering data and price list.

TRADE MARK CURTIS
UNIVERSAL JOINT CO., INC.
52 Birnie Avenue, Springfield, Mass.
As near to you as your telephone

EXCLUSIVELY A MANUFACTURER OF UNIVERSAL JOINTS SINCE 1919

Circle 506 on Page 19

Another Tinnerman Original...

Nut-in-a-cage eliminates welding or staking... **SPEED GRIPS®** hold themselves on panels!

Wherever you require a heavy-duty, multi-thread, self-retaining fastener, a Tinnerman SPEED GRIP Nut Retainer answers the need, holds down assembly costs.

SPEED GRIPS snap into place... some into panel holes... others over panel edges. No special tools or skills required. Spring-steel fingers grip the panel, yet let the nut float to compensate for normal panel-hole misalignment. Welding, staking and clinching are eliminated. SPEED GRIPS can even be applied after panels have been finished, avoiding paint-clogged threads.

SPEED GRIPS are available in a wide range of sizes and types, including front-mounting nut and bolt retainers for hard-to-reach or blind locations.

See your Sweet's Product Design File, section 8-T for data on these and other SPEED NUT Brand Fasteners. Your Tinnerman representative has complete information and samples. If he isn't listed under "Fasteners" in your Yellow Pages, write to:

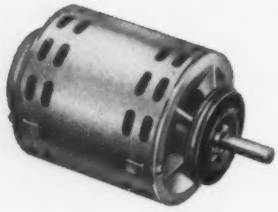
TINNERMAN PRODUCTS, INC.
Dept. 12 • P.O. Box 6688 • Cleveland 1, Ohio

TINNERMAN
Speed Nuts®

FASTEST THING IN FASTENINGS®

CANADA: Dominion Fasteners Ltd., Hamilton, Ontario. GREAT BRITAIN: Simmonds Aerocessories Ltd., Treforest, Wales. FRANCE: Simmonds S.A., 3 rue Salomon de Rothschild, Suresnes (Seine). GERMANY: Mecano-Bundy GmbH, Heidelberg.

NEW! 3 INCHES OF LOW COST POWER: HOWARD FRACTIONAL H.P. INDUCTION MOTOR



for Typewriters—Business Machines—Computors—Recorders—Appliances—

MORE POWER, SMALLER SIZE, LONGER LIFE, TOUGHER CONSTRUCTION... ALL AT LOWER COST!

• 3" diameter—26 frame size • 2 pole ratings from 15 milli-h.p. to 1/10 h.p. • 4 pole ratings from 15 milli-h.p. to 1/20 h.p. • Available in hysteresis synchronous, permanent split capacitor, split phase and capacitor start models • Single or double shaft • Resilient mount, foot mount or face mount

Write today for samples and prices!

Divisions: (EMC) Electric Motor Corp. (CS) Cyclohm Motor Corp. (LS) Loyd Scruggs Co.

HOWARD INDUSTRIES, INC. • 1735 State Street • Racine, Wisconsin

Circle 508 on Page 19

Revolutionary **BOAT TRAILER** *uses—*

NATIONAL SPRING LOCK WASHERS

—for long-life dependability

FOLLOW THE LEADERS! Improve your products and reduce production costs with NATIONAL Spring Lock Washers or NATIONAL Retaining Rings. These economical fasteners make it possible to simplify designs . . . save on materials and weight, cut down production operations, facilitate assembly. Request catalogs, or ask NATIONAL for a recommendation on your specific design application.

The NATIONAL LOCK WASHER COMPANY

Serving Industry Since 1886

NEWARK 5, NEW JERSEY • MILWAUKEE 2, WISCONSIN

Circle 509 on Page 19

HELPFUL LITERATURE

Iron Powder

Technical data bulletin on iron powder reports the results of extensive tests on grades of iron powder in performance graphs and tabular listings. Four grades of AW 100 powder covered in the report are Grade 300 with carbon addition, Grade 400 with copper addition, Grade 500 with copper-carbon, and Grade 101 with iron-lubricant addition. 8 pages. Alan Wood Steel Co., Conshohocken, Pa.

Circle 730 on Page 19

Electrical Instruments

Catalog provides data on plastic-face meters, edge-reading meters, moving-magnet units, metal-face meters, and flag-type circuit indicators. Pictures, text, and dimensional drawings provide specifications for the various units. About 18 pages. Electro-Mechanical Instrument Co., Perkasie, Pa.

Circle 731 on Page 19

Control Valves

Engineering data on square-body control valves are given in new bulletin. Bulletin reproduces cross-section drawings, dimension drawings, installation drawings, and other technical information. Seven valves are pictured and described. Described also is optional choice of two bases which permits wide latitude in mounting valves vertically or horizontally. 16 pages. Humphrey Products Div., General Gas Light Co., Kalamazoo, Mich.

Circle 732 on Page 19

Lock Nuts

Condensed catalog contains all basic engineering data and specifications for hexagon nuts, Conelok, Huglock, and Marsden lock nuts, Weldnuts, 12-pointer nuts, and 16 types of AN nuts. Brochure provides photographs, tables, line drawings, and four pages of general engineering data on terminology, design, gaging, torque, thread sizes, and screw-thread classes. 16 pages. National Machine Products Co., 44225 Utica Rd., Utica, Mich.

Circle 733 on Page 19

Miniature Filter Assembly

Bulletin 600 provides information on a miniature in-line filter assembly which has application wherever caustic and/or corrosive liquids or gases are handled. Engineering drawings and specification data are provided. Wide range of industrial and commercial applications is emphasized. 4 pages. Dumont Engineering Corp., 1401 Freeman Ave., Long Beach, Calif.

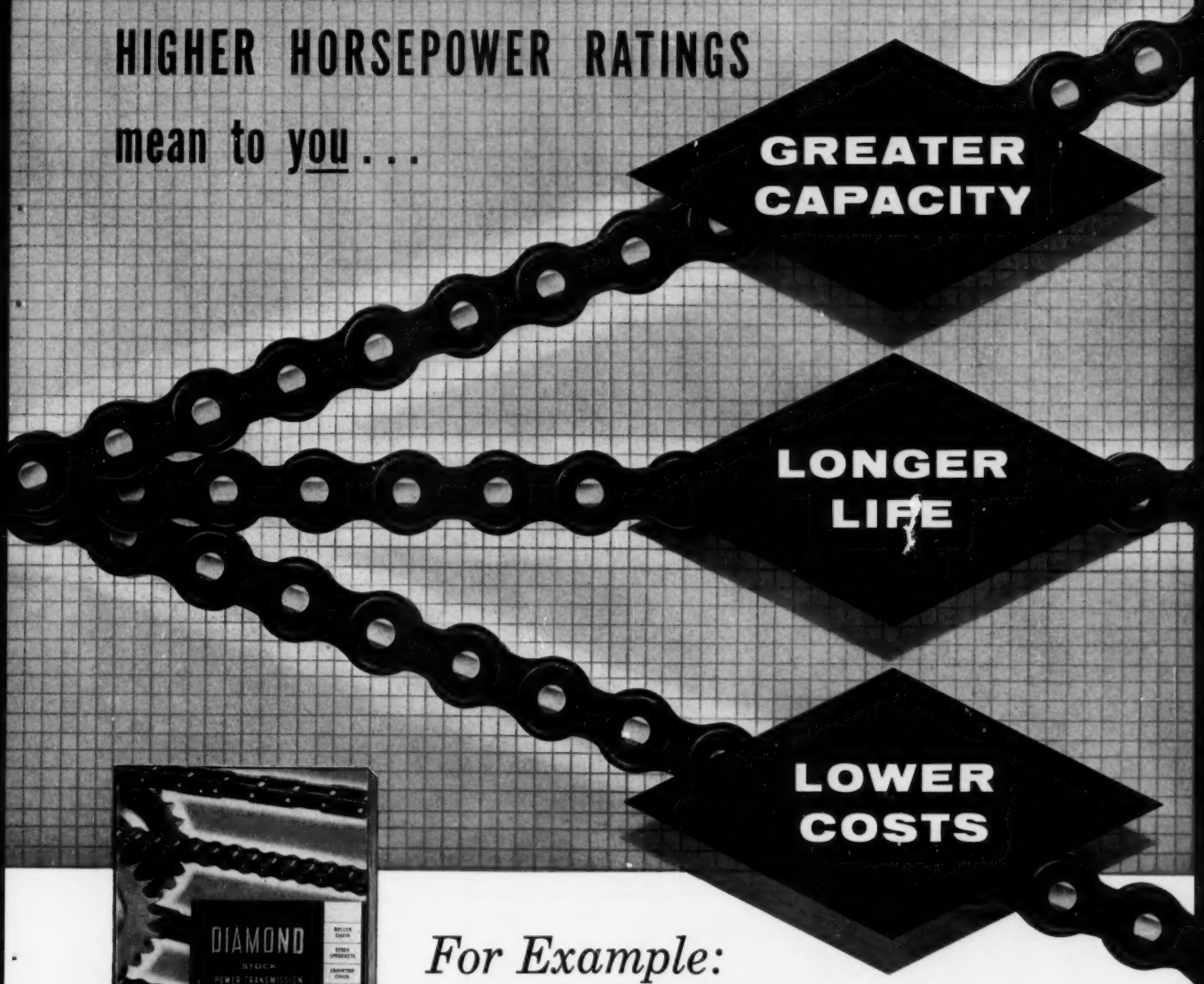
Circle 734 on Page 19

Gears, Instrument Clamps

Catalog 5A details complete line of stock precision I, II, and III gears and precision instrument clamps. Pocket-sized booklet is complete with diagrams, all dimensions, prices, and other statistics. 130 pages. Perfect Gear & Instrument Corp., 339 S. Isis, Inglewood, Calif.

Circle 735 on Page 19

Here's what DIAMOND Roller Chain's HIGHER HORSEPOWER RATINGS mean to you . . .



Write for New DIAMOND CATALOG No. 760

Just off the press. DIAMOND Stock Roller Chain, Sprocket, and Coupling Catalog No. 760 gives all the new horsepower ratings. Catalog 760 also contains full data on four important new DIAMOND Roller Chain Products: *Micropitch, Dura-Weld* and *Tuf-Flex* chains and *Hi-Cap* flexible couplings.

For Example:

Former ratings for 1 inch pitch roller chain permitted sprocket speeds up to 1160 RPM, whereas the *new* ratings include speeds up to 2800 RPM. Similarly, rated *horsepower* capacities formerly did not exceed 49 HP, whereas the new ratings exceed 150 HP. New, higher ratings mean that DIAMOND roller chains are capable of more work, will last longer (thus, cost less to operate) than heretofore considered practical. You now have more opportunities to specify high-efficiency DIAMOND Roller Chain drives . . . both in new equipment designs and in modifications of existing equipment. Write today for *new* DIAMOND Catalog No. 760. *It contains all the new ratings* as established by the Association of Roller and Silent Chain Manufacturers, of which DIAMOND is a charter member.

DIAMOND CHAIN COMPANY, INC.
A Subsidiary of American Steel Foundries
DEPT. 435 • 402 KENTUCKY AVE.
INDIANAPOLIS 7, INDIANA

Offices and Distributors in all Principal Cities

DIAMOND ROLLER CHAINS ®

Circle 510 on Page 19

...another NEW product from Stearns

... pace-setting pioneer in electro-magnetic clutches—brakes—clutch-brakes

NOW AVAILABLE—
540 lb-in. Torque Miniature Clutch Model 5.5 Style SMR*
(Shown ½ Size)

*Style SMR signifies Stationary Magnet Body, Rotor—Ball bearing mounted.

MORE TORQUE PER POUND . . .
MORE TORQUE PER CUBIC INCH . . .
weighs 24%—63% LESS, occupies 19%—64% LESS cubic area,
than other standard clutches of similar torque rating!

STEARNS STYLE SMR MINIATURE CLUTCHES						
MODEL	MAX. TORQUE	DIAMETER	DEPTH	Max. V.D.C.W.	Max. Watts	Weight
5.5	**540 lb-in.**	**5⅝″**	**2 11/32″**	**115**	**26**	**12 lb.**
5	240 lb-in.	4 5/16″	1 13/16″	90	12	5½ lb.
3.5	100 lb-in.	3⅛″	1 17/32″	90	11	3½ lb.
3.2	80 lb-in.	2⅞″	1 17/32″	90	9.6	3 lb.
3	60 lb-in.	2⅝″	1 17/32″	90	5.7	2½ lb.
2.5	30 lb-in.	2⅛″	1 17/32″	90	5.3	1½ lb.
2.2	8 lb-in.	1 13/16″	1 7/32″	90	4.6	20 oz.
1.8	2 lb-in.	1⅜″	29/32″	90	4.2	2¼ oz.

• For applications requiring high torque, high running speed, minimum size and weight. • Ball bearing mounted rotor, and stationary magnet body eliminate alignment problems — speed installations. • Can be supplied: 1. For 6, 12, 28, 90, 115 VDCW — class "A" through class "H" insulation. 2. With integral sprockets or sheaves. 3. To meet military specifications. 4. In split and thru-shaft arrangements. 5. In any combination of the above. 6. As magnetically set brakes, and as clutch-brake combinations.

• *Installation-Proved* — for *Assured Matched-to-the-Machine Performance and Long Life.* Request complete Clutch Data File 61C.

Stearns ELECTRIC CORPORATION
120 NORTH BROADWAY • MILWAUKEE 2, WISCONSIN
The Complete Line of Electromagnetic Clutches — Brakes — Clutch-Brakes
SINCE 1917—THE CHOICE OF LEADING MOTOR AND MACHINERY MANUFACTURERS

Multiple Switches

Catalog S-305 introduces new heavy-duty mounting brackets and Series 8000 and 18000 frames on nonilluminated and illuminated Multi-Switches. It also illustrates additional features, and lists engineering data, considerations, design features, and special assemblies. Line drawings, photographs, and tables are included. 8 pages. Switchcraft Inc., 5555 N. Elston Ave., Chicago 30, Ill.

Circle 736 on Page 19

Distribution Equipment

Publication GEC-1100C is a catalog covering low-voltage distribution equipment. It provides complete information on heavy-duty safety switches, CLF current-limiting fuses, hinged wireway, circuit breakers, switchboards, motor-control centers, power-distribution centers, and panelboards and busway. Included are product selector charts, descriptions, ratings, weights, and dimensions. 92 pages. Distribution Unit, General Electric Co., Plainville, Conn.

Circle 737 on Page 19

Self-Locking Nuts

New brochure shows, through photoelastic analysis, that Klincher lock nuts have holding power in excess of one and one-half times that of a standard nut. Design details are pointed out and explained, and specifications are included. 4 pages. Klincher Locknut Inc., Dept. KLL-262, 2153 Hillside Ave., Indianapolis, Ind.

Circle 738 on Page 19

Pipe, Valves, Fittings

Glassed-metal pipe, valves, and fittings are described in Bulletin 987. It presents a short paragraph on the need for glassed-metal pipe and accessories, and separate sections are devoted to the various types of units produced. Bulletin contains cutaway drawings and complete specifications and dimensions. 16 pages. Pfaudler Co., Div., Pfaudler Permutit Inc., 1126 West Ave., Rochester, N. Y.

Circle 739 on Page 19

Wave-Analysis Systems

Two automatic wave-analysis systems, a cross spectral analyzer and a two-channel analyzer for transfer function plotting, are described in Publication DB 9075. Brochure includes complete specifications, charts, formulas, and available options. 16 pages. Industrial Systems Div., Minneapolis-Honeywell Regulator Co., 10721 Hanna St., Beltsville, Md.

Circle 740 on Page 19

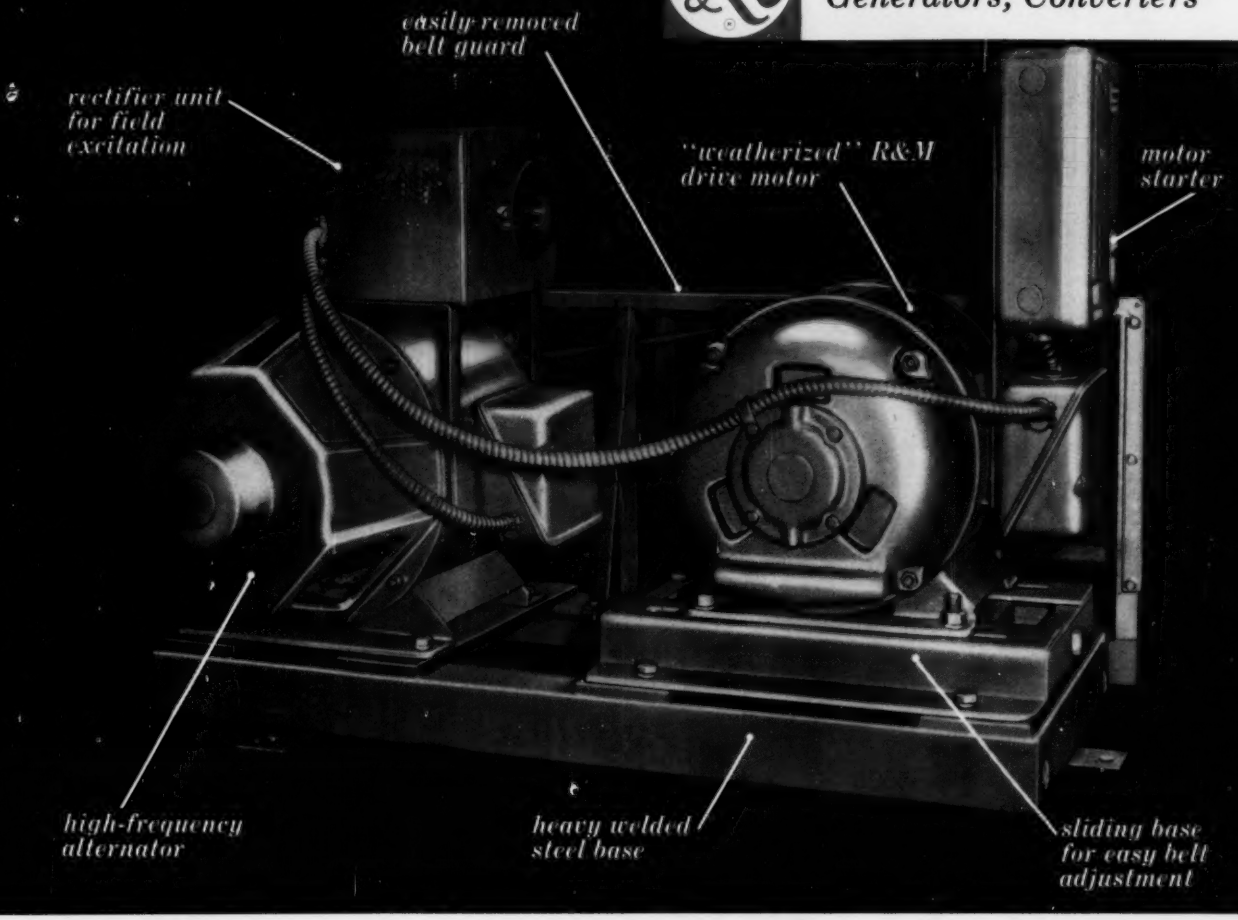
Stock Relays

Stock Relay Catalog 261 illustrates, describes, and gives specifications and prices of relays carried in stock for immediate shipment. Many types and sizes are included. 4 pages. Magnecraft Electric Co., 3350 W. Grand Ave., Chicago 51, Ill.

Circle 741 on Page 19

high frequency

Generators, Converters

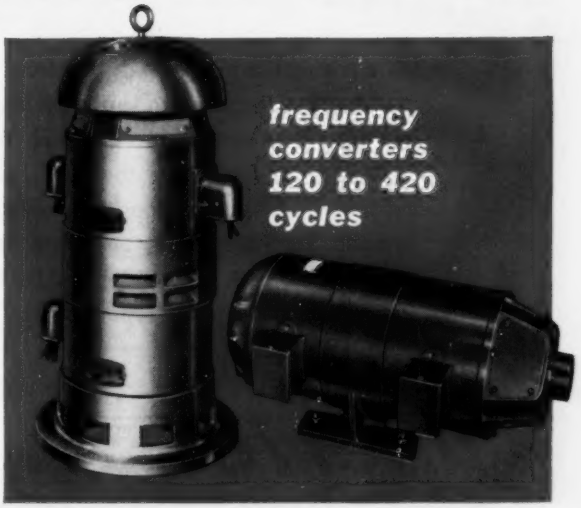


Compact High Frequency Power Generators

360 to 3300 cycles

R&M package high cycle generators provide dependable current beyond the practical range of frequency converters. Rugged revolving field construction is used in ratings of 1500 cycles and lower. Ratings above 1500 cycles are brushless inductor design. Excitation of DC alternator field is provided by simple silicon rectifiers, protected against short circuits by time-delay fuses. For changing output frequency, R&M can furnish variable pitch pulleys or variable speed drives. R&M's low-cost frequency converters make 220 volt-3 phase-120 through 420 cycle power available from 60 cycle supply . . . rated 2½KW (horizontal construction) 5, 7½ and 10KW (vertical).

Write today for bulletin 515A-MD!



ROBBINS & MYERS, INC., Springfield, Ohio

Fractional and Integral HP Electric Motors • Electric Hoists and Overhead Traveling Cranes • Moyno® Industrial Pumps
Propellair® Industrial Fans • R & M-Hunter Fans and Electric Heat • Trade-Wind Range Hoods and Ventilators
Subsidiary companies at: Memphis, Tenn., Pico Rivera, Calif., Brantford, Ontario.

Circle 512 on Page 19

Behind your Carbon Brush-
all the way!

IS STEP-BY-STEP TESTING–

It's not only the willingness to perform tests that counts, but also the experience in depth that interprets those tests and then follows through to match findings with job. With Superior Carbon Brushes you'll get the right price, freedom from trouble, long service and optimum performance for your *specific equipment* under your *specific conditions*. A vast fund of verified field data is yours to command via a Superior representative.

Ask for "Get the Most out of Your Carbon Brushes"

Superior CARBON PRODUCTS, INC.
9115 GEORGE AVENUE • CLEVELAND 5, OHIO

BRUSHES • CONTACTS • SLIP RING ASSEMBLIES
POWDER METAL PARTS • MECHANICAL CARBONS

Liquid Meter

New circular, Form 94/10-1, describes and illustrates 1½-in. stainless steel liquid meter. Circular, complete with meter specifications, points out many advantages of metering liquids. Features of the unit, including positive adjustments, easy-to-read numerals, and sealed, permanently lubricated gear train are discussed. Variety of registers is also illustrated and described. 4 pages. Neptune Meter Co., 630 Fifth Ave., New York 20, N. Y.

Circle 742 on Page 19

Fluid Accumulators

Catalog describes and pictures hydraulic-pneumatic piston accumulators, and points out their advantages. Dimensional drawings and tables are used to provide specifications and parts breakdown for the various models, and pressure-volume curves are incorporated as well. Information on charging the units is also included. About 24 pages. Fluid Power Div., Hale Fire Pump Co., Conshohocken, Pa.

Circle 743 on Page 19

Electromagnetic Relays

Comprehensive engineering data on 42 different series of electromagnetic relays is shown in new catalog. Relays are divided into four major groups: Telephone type, military, power, and general-purpose. Most of the information is presented in the form of charts for comparison between like kinds of relays. Mounting data and descriptions of a wide variety of enclosures are given, as well as information on various terminals. 16 pages. Potter & Brumfield Div., American Machine & Foundry Co., Princeton, Ind.

Circle 744 on Page 19

Air and Hydraulic Cylinders

Three new bulletins describe air and hydraulic cylinders with many improvements in cylinder design and construction. The improvements are discussed and pictured at length in the bulletin. Bulletin 202 describes air cylinders, 1½ to 14-in. bore, for pressures to 200 psi. Bulletin 203 covers medium-pressure cylinders, 500 to 2000 psi, and Bulletin 204 discusses 2000 to 3000-psi units. All three bulletins show enlarged cross-section views of cylinder construction, with detailed cylinder specifications, mounting styles, and cylinder accessories. 34 pages total. Write on company letterhead to Mo-Bar Hydraulics Co., Crystal Lake, Ill.

Panel Instruments

New technical catalog provides detailed specifications, outline drawings, and general information covering a wide range of miniature and full-size electrical indicating panel instruments. Sizes from ½ to 4½ in. diam are included. Photographs are provided for all units. 24 pages. Write on company letterhead to Electronic Sales Div., DeJur-Amsco Corp., 45-01 Northern Blvd., Long Island City 1, N. Y.

Circle 513 on Page 19

PRODUCT-DESIGN BRIEFS FROM DUREZ

- **Something extra in molding compounds**
- **Fire-retardant structural plastic**
- **News notes for designers**

Upgrading a product

Good • Plenty of distributor caps are molded of Durez general-purpose phenolic. When cost is a prime factor, general-purpose does the job and does it well.

Best • However, if you're shooting for something extra in a distributor cap (or in almost any electrical part), take a look at *Durez 2271*. This is an electrical-grade phenolic. A ⅛" test disk of it withstands 12 kv at 180° F in air for an hour or more without puncturing. The cost of this extra performance is low: weighing less than comparable electrical-grade materials, *2271* gives you more pieces per pound.

Good • You'd be right in choosing *Durez 791 Black* for a piece like this telephone handset. You'd be able to count on low molding cost because of *791's* fast cure. You'd get the required physicals in good balance. And the price of this wood-flour-filled material is low.

Best • Then why do telephone men favor a different material, *Durez 17225*, for handsets? Because this wood-flour-and-flock-filled material provides even higher resistance to impact fractures. The rich black finish presents an unyielding front to moisture and body acids. Bonus: a part that *more* than meets the specs—for fractions of a penny per piece.

We could go on and on giving you case histories like these. Have you looked into the extras you can build into a product—at next-to-invisible cost—with Durez molding materials? To get a better idea of what these compounds can do for you, send for our illustrated 8-page Bulletin D400 listing properties, uses, advantages.

CONSOLITE (CONSOLIDATED GENERAL PRODUCTS, INC.)

Safer skylight

Here's a plastic skylight that retards fire.

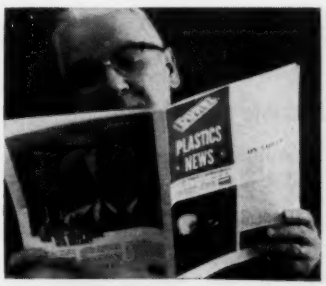
It's made for use in hazardous locations or wherever building codes are exceptionally strict.

The material is fibrous-glass-reinforced Hetron®. It will ignite only under direct hot flame, and snuffs out as soon as the flame source is removed.

Weighing only half a pound per square foot, the skylight material will support a uniform load of 150 pounds per square foot. It is thermally stable from −65° to 200° F, and has great strength and shatter resistance even at subzero temperatures.

Its thermal conductivity is only ⅕ that of glass, yet it can transmit ⅘ as much light as glass without glare. It delivers greater insulating effect than other skylight materials, at lower cost.

Could any of these attributes help *you* design a better product? Hetron® is hard at work already in radomes, chemical ducts, blowers, boat hulls, housings, fume hoods, window panels, canopies. Data on self-extinguishing Hetron resins is yours for the asking.



On keeping abreast

How can a man keep up with all that's new in thermosetting plastics?

Well, it isn't easy. But we can help. We mail out every 60 days a bulletin, *Durez Plastics News*. You can read it in 10 minutes. It gives a bird's-eye view of what's new in the use of Durez plastics. Every item is *news*—hot off the presses of leading molders the country over, whom we visit regularly.

To get this bimonthly packet of ideas and information, just check the coupon.

For more information on Durez materials mentioned above, check here:

- ☐ Phenolic molding compounds (8-page Bulletin D400).
- ☐ Hetron fire-retardant polyester resin (data file).
- ☐ *Durez Plastics News* (mailed bimonthly).

Check, clip, and mail to us with your name, title, company address.
(When requesting samples, please use business letterhead.)

DUREZ PLASTICS DIVISION
502 WALCK ROAD, NORTH TONAWANDA, N. Y.
HOOKER CHEMICAL CORPORATION
HOOKER CHEMICALS PLASTICS

Circle 514 on Page 19

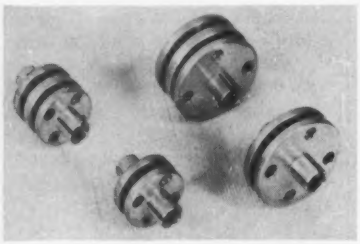
New Parts and Materials

Use Yellow Card, page 19, to obtain more information

Flexible Couplings

miniature units transmit 15 to 40 lb-in of torque

Line of miniature flexible couplings has been expanded to include 12 new models and/or sizes. Sizes range from $\frac{5}{8}$ to 1 5/16 in. OD, and bore sizes from 0.0937 to 0.6875 in. Pancake and split-hub units transmit 15 to 40 lb-in. of torque at high speeds. There are no moving parts to wear, there is no friction, and nothing to be lubricated on the all-metal units. Couplings are torsionally rigid with no backlash and provide a smooth, constant drive. They absorb angular misalignment to $7\frac{1}{2}$ deg, lateral misalignment to 0.015 in., and axial movement to 0.060 in. in a single unit. They also dampen vibration effectively. **Dial Products Co.**, 19 Cottage St., Bayonne, N. J.

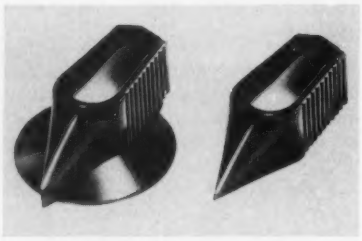


Circle 745 on Page 19

Bar-Pointer Knobs

meet Military Spec MIL-K-3926

Parallax virtually has been eliminated in two bar-pointer knobs. Available colors are black or gray per MS92528B. Models have a 7/8-in. swept turning radius and are available in the 90 Series for $\frac{1}{4}$-in. shafts. New styles include a dial-skirted bar-pointer and a plain bar-pointer. Injection-molded of acrylonitrile-styrene copolymer, they contain an aluminum bushing. Supplied with each knob are two cup-point, socket-type 4-40 UNC 3A set screws. High-gloss mirror finish for industrial use or nonreflective matte finish for military use are available in either color. **Industrial Components Div., Raytheon Co.**, 55 Chapel St., Newton 58, Mass.

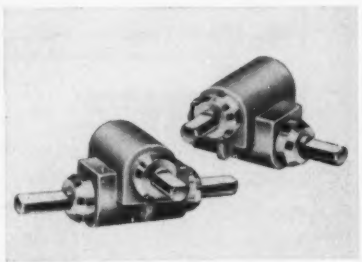


Circle 746 on Page 19

Angle Drives

have static torque capacity of 25 lb-in.

Two angle drives, designated 9056HF (T-drive) and 9056-119 (right-angle drive) are provided with $\frac{1}{4}$-in. diam shafts cut to a 1/16-in. flat to provide a strong attachment for coupling ends. Primarily used with flexible shafting, the adaptors allow for a wide variety of uses. Constructed of aluminum-alloy housing, the units have steel gears and utilize Oilite bearings. They have an ultimate static torque capacity of 25 lb-in. with a backlash of 6 deg, and weigh 4 and $3\frac{1}{2}$ oz. respectively. Units are furnished in gear ratios of 1:1, 1:2, and 2:1, with other ratios available upon special request. Outlet end of the angle drives can be furnished to rotate in either the same or the opposite direction as the input end. **F. W. Stewart Corp.**, 4311-13 Ravenswood Ave., Chicago 13, Ill.

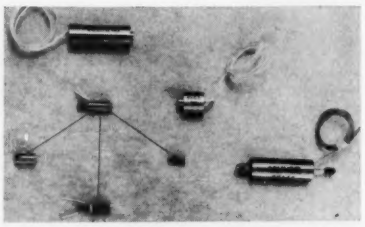


Circle 747 on Page 19

Miniature Solenoids

for use in electromechanical systems

Series of miniature solenoids meets requirements of MIL-S-4040C. They are manufactured with diameters of $\frac{1}{4}$, 5/16, and $\frac{1}{2}$ inch, voltages of 6, 12, 24, 36, 115, and 230 vdc, and power ratings of $\frac{1}{4}$ w up. They can be used for applications in digital computers, printers, punched tape block readers, automatic calculators, code bar switches, high-speed printers, integrated data-processing equipment, tape readers, telemetry equipment, electronic counters, X-Y plotters, loggers, digital modules, and other electromechanical systems. Photo shows only a few representative types. **Cannon Electric Co.**, 3208 Humboldt St., Los Angeles 31, Calif.



Circle 748 on Page 19

Nut and Lockwasher

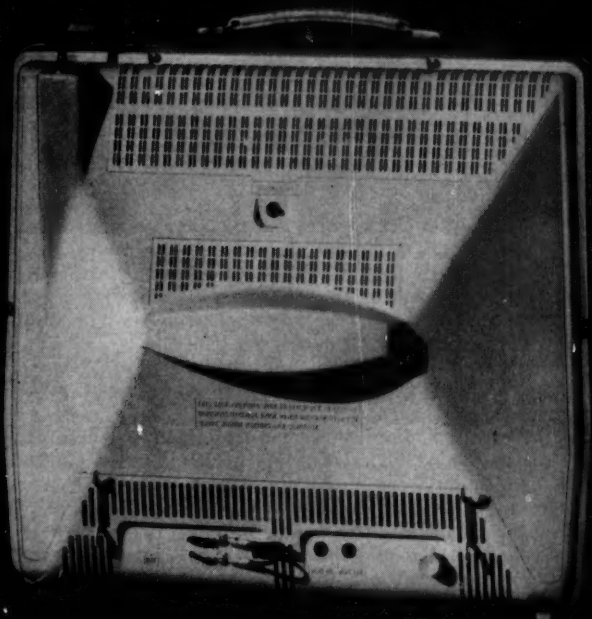
preassembled units come in 5/16 and $\frac{3}{8}$-in. sizes

Nuts fastener consists of a preassembled hex nut and helical-spring lockwasher joined together by means of a special adhesive. In addition

there are always good reasons for designing it in

AVISUN

polypropylene



AviSun Polypropylene's good molding characteristics permit an intricately vented back with cross-members less than 1/8 inch wide. Custom-molded by Sinko Tool & Mfg. Co.

in TV backs *it's toughness, heat resistance, good insulation*

Styling is most important in portable TVs. For the backs of their sets, Motorola needed an attractively molded back with good insulating properties, high heat resistance, and tough enough to stand hard bumps. Only polypropylene could meet their quality specifications. The back, molded in one piece from AviSun polypropylene, is warp-free, economical to manufacture, and easy to assemble.

Polypropylene makes better products at lower cost. No other material has this combination of properties:

1. **Heat Resistance**
2. **Chemical Resistance**
3. **Toughness**
4. **Economy**

AviSun's technical specialists will gladly assist you with specific applications—write, or phone LOcust 8-5520.

AVISUN

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Mail coupon for technical information

AVISUN CORPORATION
Dept. 443, 1345 Chestnut St.
Philadelphia 7, Pa.

Send me Booklet AP-601 covering full technical information on AviSun Polypropylene.

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COMPANY_____

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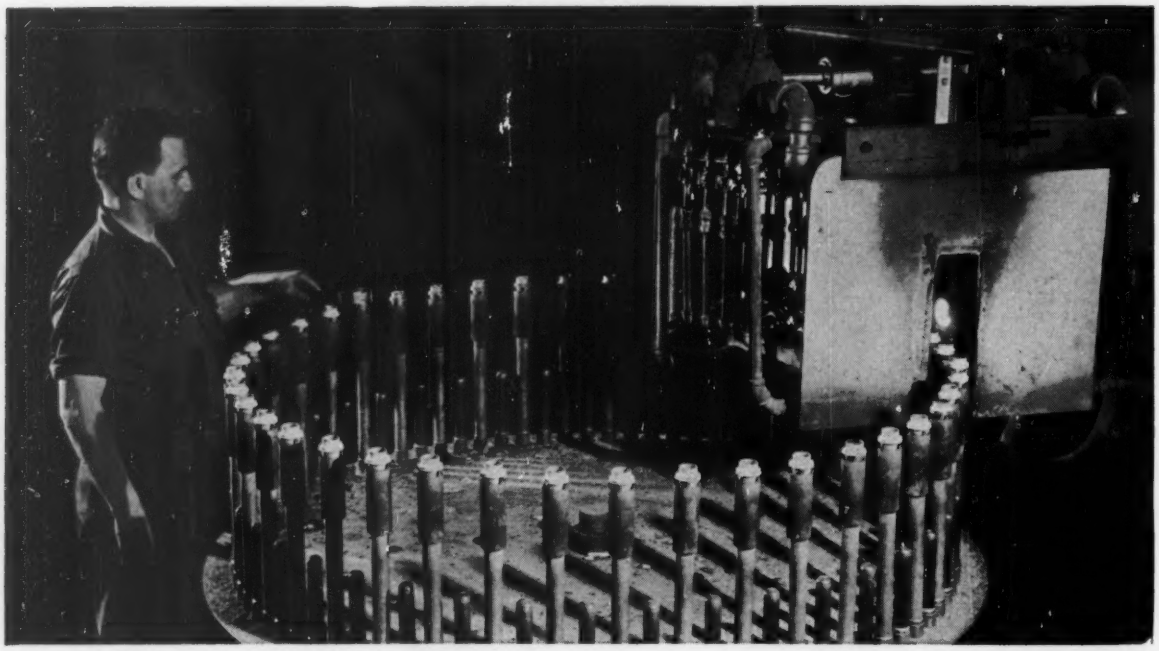
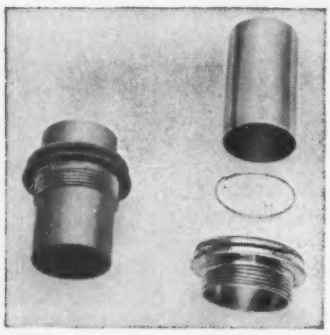
CITY_____ STATE_____

Every Hour M. S. Little Brass Goods Company Makes 650 Appliance Fittings Better With HANDY & HARMAN SILVER BRAZING



Rotating jig showing mounted assemblies entering and leaving gas-air furnace.



Left– brazed assembly. Right– components with preform ring of EASY-FLO *45.*

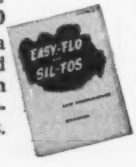
This Hartford, Connecticut, company makes—in volume—an assembly that goes into the overflow system of household appliances. The assembly consists of brass tubing and a machined brass casting. The two components are joined by a preplaced ring of Handy & Harman EASY-FLO 45 silver brazing alloy and HANDY FLUX. Heating is automatic gas-air; parts are placed on a rotating turntable to pass through the gas furnace. Every 60 working minutes, 650 assemblies are completed.

The advantages here are that the manufacturer can use thin-walled tubing with heavier, threaded components at no sacrifice in strength. Because of EASY-FLO's penetrating qualities, the entire shear area is fully as strong as the solid parts of the assembly, yet considerably lighter. And, casting and machining the components for this assembly have been greatly simplified.

Are you in pursuit of a metal-joining method which offers—among other advantages—high, uninterrupted production at low capital investment? You may easily find the answer in Handy & Harman silver brazing. Hundreds of manufacturers and fabricators of as many different products, parts and components are right now enjoying the speed, economy, strength and *flawlessness* of brazing. You can too. Just ask Handy & Harman, 82 Fulton Street, New York 38, N. Y.

FOR A GOOD START: BULLETIN 20

This informative booklet gives a good picture of silver brazing and its benefits... includes details on alloys, heating methods, joint design and production techniques. Write for your copy.



Your No. 1 Source of Supply and Authority on Brazing Alloys

HANDY & HARMAN

General Offices: 82 Fulton St., New York 38, N. Y.

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San Francisco, Calif.
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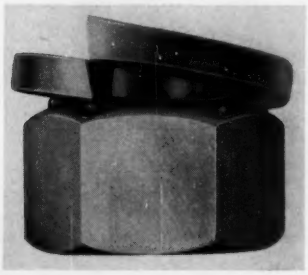
Toronto, Canada

Circle 516 on Page 19



to reducing assembly time, units counteract any looseness due to factors causing loss of tension in assembled parts. Fasteners are available initially in 5/16 and 3/8-in. sizes, fine and coarse threads, plain and plated finishes. **Philadelphia Steel & Wire Corp.**, Penn Street & Belfield Ave., Philadelphia 44, Pa.

Circle 749 on Page 19

Alloyed-Iron Material

for roller-bearing retainers

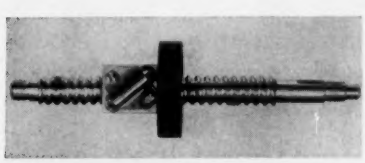
Rolltube alloyed-iron material operates at temperatures to 800 F. Available for roller-bearing retainers, it has a coefficient of expansion close to that of steel, and operates satisfactorily under conditions of boundary lubrication. Permanent expansion or growth at elevated temperatures is much lower with the new material than with bronze. Rolltube also is lighter than bronze, and has a yield strength about 1½ times that of bronze. **Rollway Bearing Co. Inc.**, 541 Seymour St., Syracuse 4, N. Y.

Circle 750 on Page 19

Ball-Bearing Screws

are freewheeling at both ends of travel

New ball-bearing screws assure precision positioning with minimum power, size, and cost. They permit limiting the travel of the nut at predetermined positions with continuing rotation of the screw. Freewheeling action is accomplished by providing a stop in the screw at each



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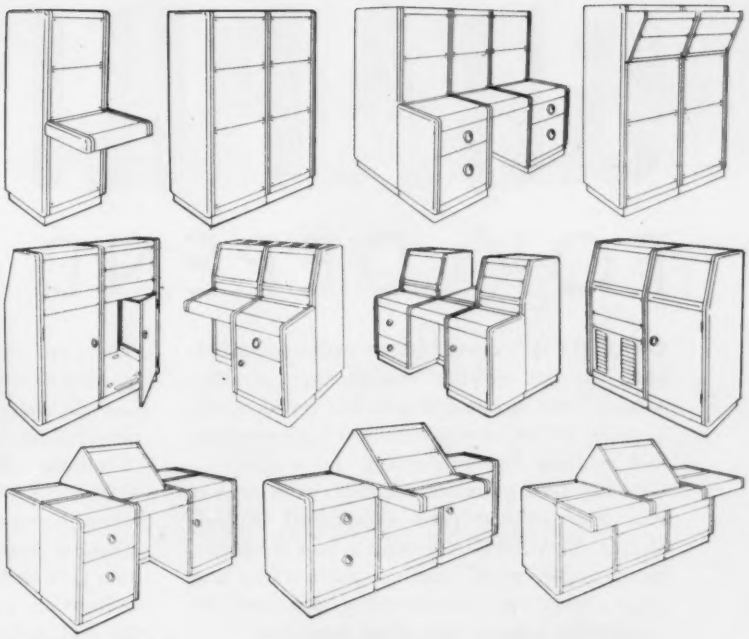

HUNDREDS OF BASIC EMCOR STANDARD FRAMES TO BUILD YOUR ENCLOSURE SYSTEM

Just a few of the thousands of control center combinations, attained through the use of the EMCOR MODULAR ENCLOSURE SYSTEM, are illustrated here. The ultimate in enclosure flexibility is available through hundreds of EMCOR Standard Basic Frames and thousands of component parts. The EMCOR Fine Line of Quality features simplicity in assembly. With a standard screwdriver, you can assemble a control center to meet your electronic, instrument or electromechanical housing problem. You eliminate costly enclosure design time and modification of custom type units. Only EMCOR, the originator of the Modular Enclosure System, provides the ultimate in design, beauty, rugged structural capabilities and quality controlled craftsmanship in the fabrication of metal enclosures. Let EMCOR "Know-How" serve and save for you!

Condensed Version of Catalog 106 Available Upon Request.

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Originators of the Modular Enclosure System

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Circle 517 on Page 19

GRAPHITAR®

(CARBON-GRAPHITE)

FOR DEPENDABILITY

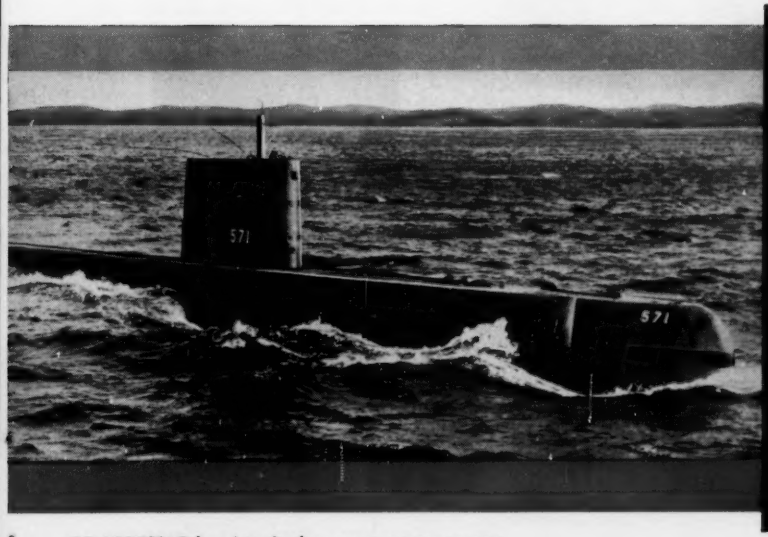
GRAPHITAR'S own character makes it dependable. A non-metallic engineering material, formed from carbon and graphite powders and a special binder, compacted under high pressures and furnaced at temperatures up to 4,500°F., GRAPHITAR possesses inherent characteristics that give finished parts exceptional dependability. GRAPHITAR'S natural heat resistance, for example, gives bearings, seals, vanes and rings exceptional dependability whenever dependability is one of the prime requisites.

There are other characteristics every bit as important to GRAPHITAR'S dependability. They include chemical and magnetic inertness, mechanical strength and adaptability to self-lubrication. Besides these natural characteristics, GRAPHITAR engineers can control porosity, strength and hardness to match GRAPHITAR'S physical properties to each individual application. It's little wonder that GRAPHITAR has become one of the design engineer's most versatile and useful materials.

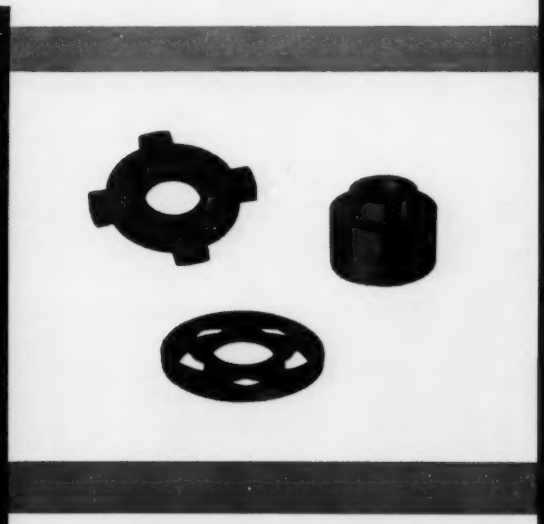
In this laboratory test stand, oxidation-resistant GRAPHITAR parts are being checked under simulated operating conditions. Similar tests have proven that, when GRAPHITAR parts are exposed in oxidizing atmospheres at 1,200°F., they show only a weight loss of less than six percent after 200 hours.

In the Engineering Department of The United States Graphite Company, micro-photo studies are indispensable in the study of internal part structure. The Metallograph is just one of dozens of modern technological aids employed in both the quality control of production GRAPHITAR parts and in the research and development of new products. GRAPHITAR parts are engineered for dependability.

GRAPHITAR air/oil seals employed in today's high-speed turbojet engines have established an enviable record for operating dependability. Installed on the main shaft of the turbine, GRAPHITAR seals successfully withstand tremendous shaft speeds and generated heat.



GRAPHITAR bearings in the power reactor pumps of American nuclear submarines have compiled an outstanding record for dependability.



Unusually shaped parts of GRAPHITAR can be molded easily with today's modern techniques. Ears, face slots and outside diameter notches of friction disc above, left, were molded in one operation without need for secondary machining and finishing.

Do you have an application in which GRAPHITAR'S dependability can help solve a tough problem, reduce your costs and improve the operational life of your products? Our engineering staff can help you find out. Our field men can also give specialized, on-the-job consultation. Send for your free copy of Engineering Bulletin #20. Included is helpful information about the properties, characteristics and applications of GRAPHITAR.

THE UNITED STATES GRAPHITE COMPANY

DIVISION OF THE WICKES CORPORATION, SAGINAW 7, MICHIGAN

GRAPHITAR® CARBON-GRAPHITE • GRAMIX® POWDER METALLURGY • MEXICAN® GRAPHITE PRODUCTS • USG® BRUSHES

Circle 518 on Page 19

R-294-2

Nylatron® GS Wear Strip eliminates lubrication

By using a .020" thick NYLATRON GS nylon strip between the feeder tube stock reel and its support base on this screw machine, lubrication and messy oil drip were completely eliminated. Economical NYLATRON GS, with non-galling, non-scratching characteristics, also prevented abrasive wear on the sliding metal surfaces, and the strip lasts for years.

Photo: Courtesy Dick Bros., Inc.

NYLATRON GS (a compound of nylon and molybdenum disulphide*) offers both manufacturers and users many advantages over regular nylon and metals in applications such as this. In addition to its self-lubrication characteristics, NYLATRON GS has greater wear resistance, higher strength, greater rigidity, superior heat resistance and improved dimensional stability. Yet it costs no more than standard nylon.

NYLATRON GS stock shapes are available in a complete range of rod, strip, tubing and plate forms. Rapid, low-cost fabrication is accomplished on standard metalworking equipment. Molding powders are also available.

Complete stocks and technical services are as close as your telephone. See your classified directory, or write today for full information.

*Patented

POLYPENCO industrial plastics

The Polymer Corporation of Pennsylvania

Reading, Pa.

Export Polypenco, Inc., Reading, Pa., U.S.A.

(Continued from Page 205)

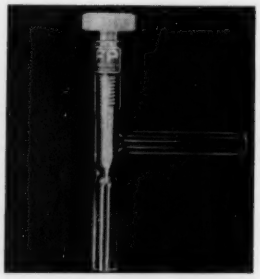
end of the desired nut travel, and a simple freewheeling device, which is an integral part of the nut assembly. There is no need for limit switches or other devices. With the exception of the stops and freewheeling device, units are similar to conventional ball-bearing screws and nuts. Load-carrying capacities are the same as conventional screws of the same size. Versatility of the units permits them to be used for a variety of actuation applications. **Saginaw Steering Gear Div., General Motors Corp.**, Saginaw, Mich.

Circle 751 on Page 19

Needle Valve

has maximum orifice of 0.05 in.

Threaded-glass and Teflon needle valve provides fine fluid control and permits continuous visual observation of flow. Wetter tip of the



glass needle valve is of chemically inert Teflon which will not corrode or leak; valve stem is Kel-F, sealed with a Viton-A O-ring. Valve has a maximum orifice of 0.05 in. and has been used successfully in vacuum applications down to 10^{-6} mm of mercury. **Fischer & Porter Co.**, 720 Jacksonville Rd., Warminster, Pa.

Circle 752 on Page 19

Latch Relay

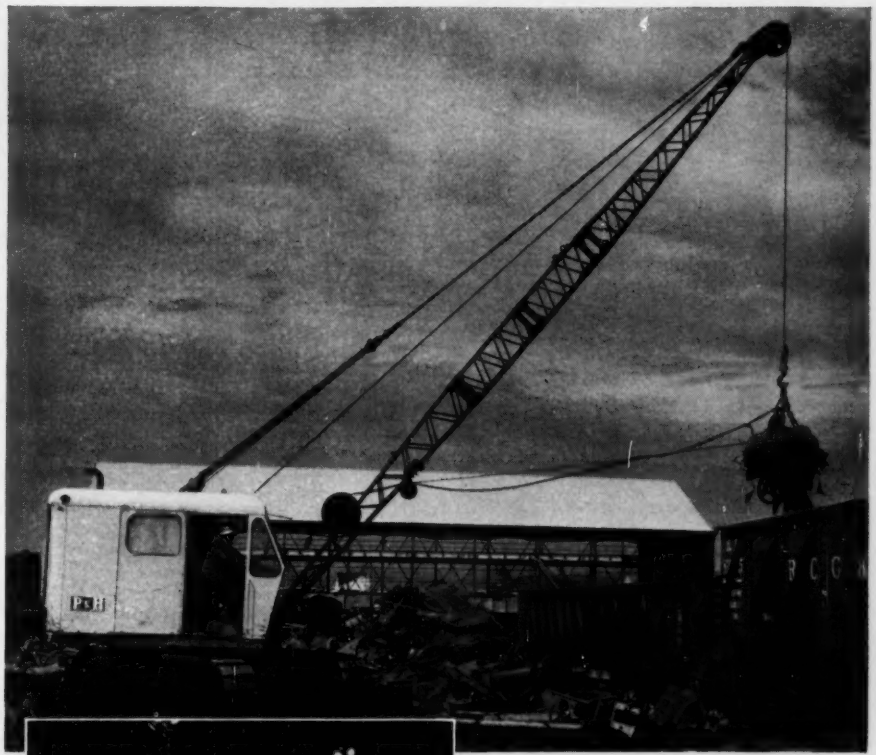
for printed-circuit use

Microminiature sensitive latch relay features a magnetic latch system which maintains an actuated condition without continuous power drain. It utilizes rotary balanced-armature construction, allowing relay to meet extremes of vibration and shock. SPDT unit has sensitivity at pull-in at 25 C of 25 mw

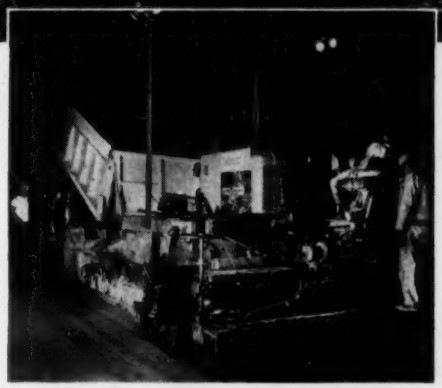
Circle 519 on Page 19

When dependable electric power is the lifeblood of your equipment

Specify Onan Generators. Rugged, reliable, all-climate. Built by the world's leading builder of generator sets.



BIG PICKUP! Plenty of lifting power here with Onan's specially designed Generator for electro-magnet service. Steady, reliable power assures maximum payload every time. Electrify *your* equipment with its main engine and an Onan Generator.



ELECTRIC POWER ON THE MOVE! Versatile 120-240 volt, 60-cycle, single phase Onan Generator powers both the heater burner and screen vibrators on this bituminous road paver. What's *your* electric power problem? Let Onan help!

WORLD'S LEADING BUILDER OF GENERATOR SETS

Onan®

Onan Division,
Studebaker-Packard Corp.
2719 University Ave., S.E.,
Minneapolis 14, Minn.

Circle 520 on Page 19

Off-shelf, modified or custom designed models

You'll never have to settle for an "almost as good" generator from Onan, because we'll modify or custom design to fit your exact requirements. Solving electric power problems has been our specialty for more than 30 years—more skill and experience at Onan than you can get from any other source.

Tell us your AC or DC power needs, for (1) general use, such as construction or agricultural equipment, (2) magnet use, or (3) battery charging. Whether direct from stock, modified or custom designed—Onan generators will fit your special requirements best.

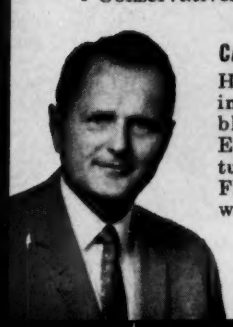
TYPICAL ONAN GENERATORS AVAILABLE FROM STOCK

AC REVOLVING ARMATURE: 1½ to 10 KW.

KW RATINGS	A-C	D-C
60-cycle 1800 rpm	1½, 2½, 4, 7, 10	
50-cycle 1500 rpm	2, 3, 5, 8,	
general use, 1750 rpm		2, 5
magnet use, 1750 rpm		10, 15
Battery chargers		1½, 2, 3, 5
Dimensions, approx. inch	min. max.	min. max.
height, inc. ring	13¾ 18	17½ 17½
length, inc. shaft	16⅜ 26⅜	24 25⅜
width	11½ 15¼	17⅜ 17⅜
Weights, approx. lb.	100 400	115 400
Also available 4, 7, 12 KW. PTO generators.		

ALL THESE SPECIAL FEATURES ARE STANDARD ON ONAN

- Heavy-duty rolled steel frames
- Laminated, balanced armatures
- Form wound, fully-taped field coils
- All-climate insulation
- Drip proof
- Ball bearing construction
- Rotate either direction
- Conservatively rated

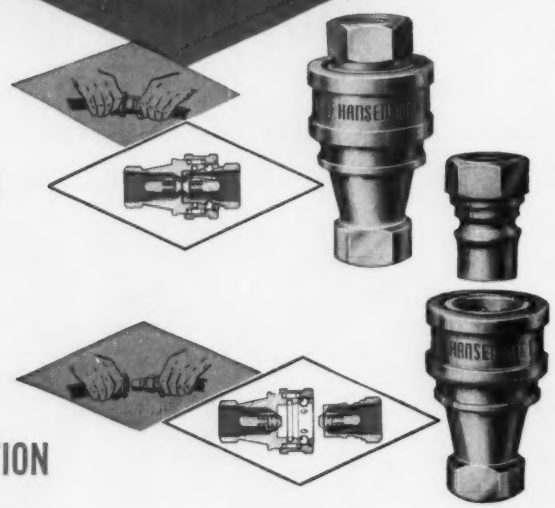


CALL BOB WESTRUM. He's an expert in solving generator problems for Original Equipment Manufacturers. Minneapolis, FEderal 2-1155. Or write.

HANSEN

SERIES HK* QUICK-CONNECTIVE

TWO-WAY SHUT-OFF COUPLINGS



QUICK CONNECTION

with instant automatic flow

QUICK DISCONNECTION

with instant automatic shut-off

...prevents loss of liquid, gas, or pressure

As easy as plugging in your electric shaver...

Write for the Hansen Catalog

Here is an always ready reference when you want information on couplings in a hurry. Lists complete range of sizes and types of Hansen One-Way Shut-Off, Two-Way Shut-Off, and Straight-Through Couplings—including Special Service Couplings for LP-Gas, Steam, Oxygen, Acetylene, etc.

To connect a Hansen Two-Way Shut-Off Coupling, you merely pull back the sleeve and push the Plug into the Socket. To disconnect, just pull back the sleeve. No tools required. When Coupling is disconnected, similar valves in Socket and Plug shut off both ends of fluid line circuit—practically eliminating spilling of fluid at instant of disconnection.

Available in brass or steel, with female pipe thread connections from ⅛" to 1½" inclusive.

Representatives in Principal Cities ...see Yellow Pages

SINCE 1915 — QUICK-CONNECTIVE FLUID LINE COUPLINGS

THE HANSEN MANUFACTURING COMPANY

4031 WEST 150th STREET • CLEVELAND 35, OHIO

or better; DPDT unit has sensitivity of 40 mw or better. Temperature range is −65 to +125 C. Long or short leads are available for printed-circuit boards, or hook terminals are furnished for standard wiring. Brakets, studs, or straps are available for mounting if desired. **Hi-G Inc.**, Bradley Field, Windsor Locks, Conn.

Circle 753 on Page 19

Miniature Ball Bearings

in sizes from ⅜ to ⅝ in. OD

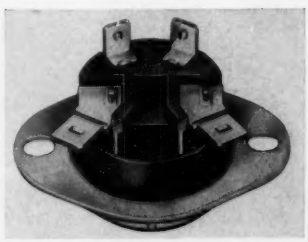
Inch Series class ABEC-7 instrument ball bearings incorporate deep-groove, high-shoulder raceways for expanded contact ellipse, and a loose-clinched ribbon retainer to provide minimum breakaway torque and freedom from hangup. Improved curvature design provides stress equalization at inner and outer races for high capacity. Series is completely interchangeable with other makes of similar bearings. Size range is ⅜ to ⅝ in. OD. **Reed Instrument Bearing Co., Div., SKF Industries Inc.**, Front Street & Erie Ave., Philadelphia 32, Pa.

Circle 754 on Page 19

Appliance Thermostat

incorporates a line voltage heater

Klixon 20450 disc-type thermostat,



ASARCON

custom shapes and forms in any lengths you need

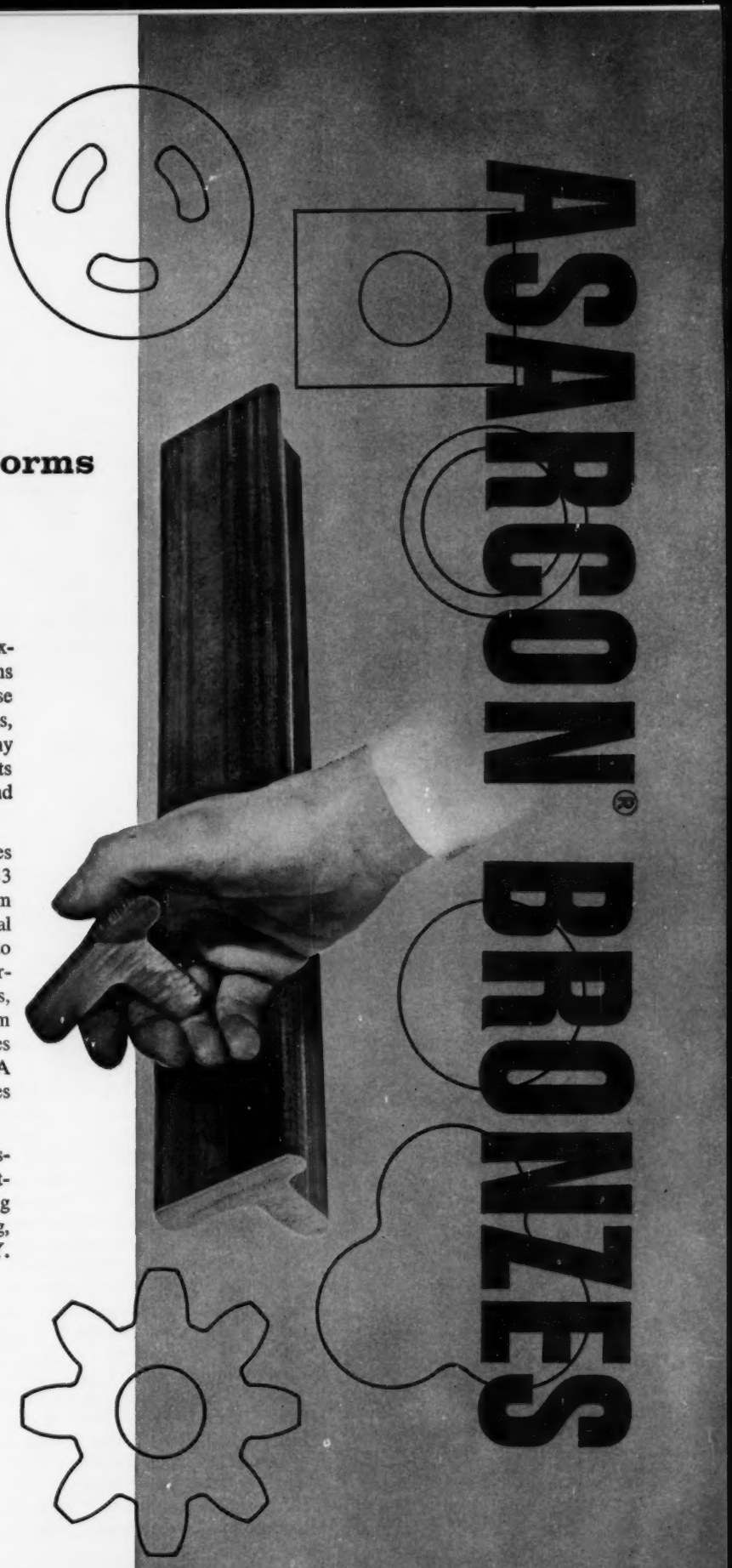
Asarcon continuous castings give you an extremely wide variety of shapes and forms in standard bronze alloys. They will increase your production rates and lower your costs, because: you get the shape you want in any length you need up to 20 feet. This permits machining on automatic screw machines and other high-speed equipment.

Continuous casting of Asarcon bronzes raises fatigue characteristics of standard alloys 33 to 100%, increases impact strength from 15% to more than double that of identical alloys cast other ways, adds materially to tensile, yield strengths and hardness. Asarcon 773 (SAE 660) bearing bronze in solids, rods and tubes is immediately available from stock in your choice of more than 260 sizes up to 9″ O.D. and lengths up to 105″. A wide variety of other special alloys, shapes and sizes produced to order.

For complete data on Asarcon continuous-cast bronze, write Continuous-Cast Department, American Smelting and Refining Company, Perth Amboy, N. J., Whiting, Ind.; or 120 Broadway, New York 5, N. Y.

ASARCO

Circle 522 on Page 19



(Advertisement)

Eastman 910 Adhesive solves another production bottleneck

Atkins & Merrill, Inc., industrial model makers, of South Sudbury, Massachusetts, produce quarter-scale cut-away models of the famous Pratt & Whitney J-57 TurboWasp jet aircraft engine.

Highly detailed, the model contains several compressor and turbine rotors, driven by concealed motors. More than 1,600 small die cast zinc alloy blades are attached to zinc alloy rotors.

Fastening the blades posed a problem, however, as soldering or welding generated excessive heat, causing the blades to warp.

The problem was solved with high-strength Eastman 910 Adhesive. It sets quickly without heat, requires only contact pressure. To date, more than 70,000 blades have been bonded.

Eastman 910 Adhesive is making possible faster, more economical assemblyline operations and new design approaches for many products. It is ideal where extreme speed of setting is important, or where design requirements involve joining small surfaces, complex mechanical fasteners or heat-sensitive elements.

Eastman 910 Adhesive is used as it comes. No mixing, no heating. Simply spread the adhesive into a thin film between two surfaces. Light manual pressure triggers setting. With most materials, strong bonds are made within minutes.

What production or design problems can this unique adhesive solve for you?

For a trial quantity (⅓-oz.) send five dollars to Armstrong Cork Co., Industrial Adhesives Div., 9110 Dean Street, Lancaster, Pa., or to Eastman Chemical Products, Inc., Chemicals Div., Dept. M-2, Kingsport, Tenn. (Not for drug use)
See Sweet's 1960 Prod. Des. File, 7/E

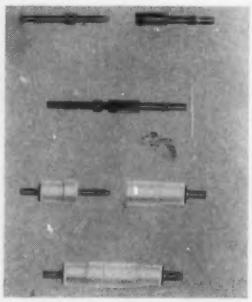
Circle 523 on Page 19

designed primarily for control systems in appliances, anticipates temperature when a built-in internal heater operates. Basic thermostat has a diameter of 1.181 in., height of 1.131 in., and weight of 1 oz. It is furnished with a single-pole, single-throw contact arrangement in two contact structures: As a fan switch (circuit closes on temperature rise), and as a high-limit switch (circuit opens on temperature rise). Thermostat is also available with single-pole, double-throw switching action. With a variety of standard flanges, control is flexible in mounting. Silver-plated, quick-connect terminals are standard. Maximum ambient temperature is 200 F. Maximum heater rating is 5 w, and maximum heater voltage is 120 v ac. **Spencer Products Group, Metals & Controls Div., Texas Instruments Inc.**, 34 Forest St., Attleboro, Mass.

Circle 755 on Page 19

Teflon-Insulated Connector

for single or multiple connector use



Single-pin, compression-mounted, Teflon-insulated, male-female connector, originally developed as part of a rack-and-panel connector for use in the qualification and reliability testing of components, is adaptable for single or multiple-connector use. Connector makes contact continually at one specific point on the male shaft through use of a fixed, spun female contact ring. Unit withstands temperatures to 200 C, varying humidity, and salt spray. "Floating" the brass male and female connectors in Teflon housings by means of E-ring retainers allows for tolerance build-ups of as much as 0.005 in. off per connector. In use, Teflon-insulated terminal is compression-mounted directly

THE FREEDOM DIMENSION

. . . means alloy flexibility

Through investment casting, your metal parts can be made in a wide range of ferrous, nonferrous and super alloys. Results — better performance...longer life...lower costs!

This part for can making machinery now cast in a non-machinable alloy offers a very high degree of resistance to wear and corrosion. Results — costly parts replacement problems ended.

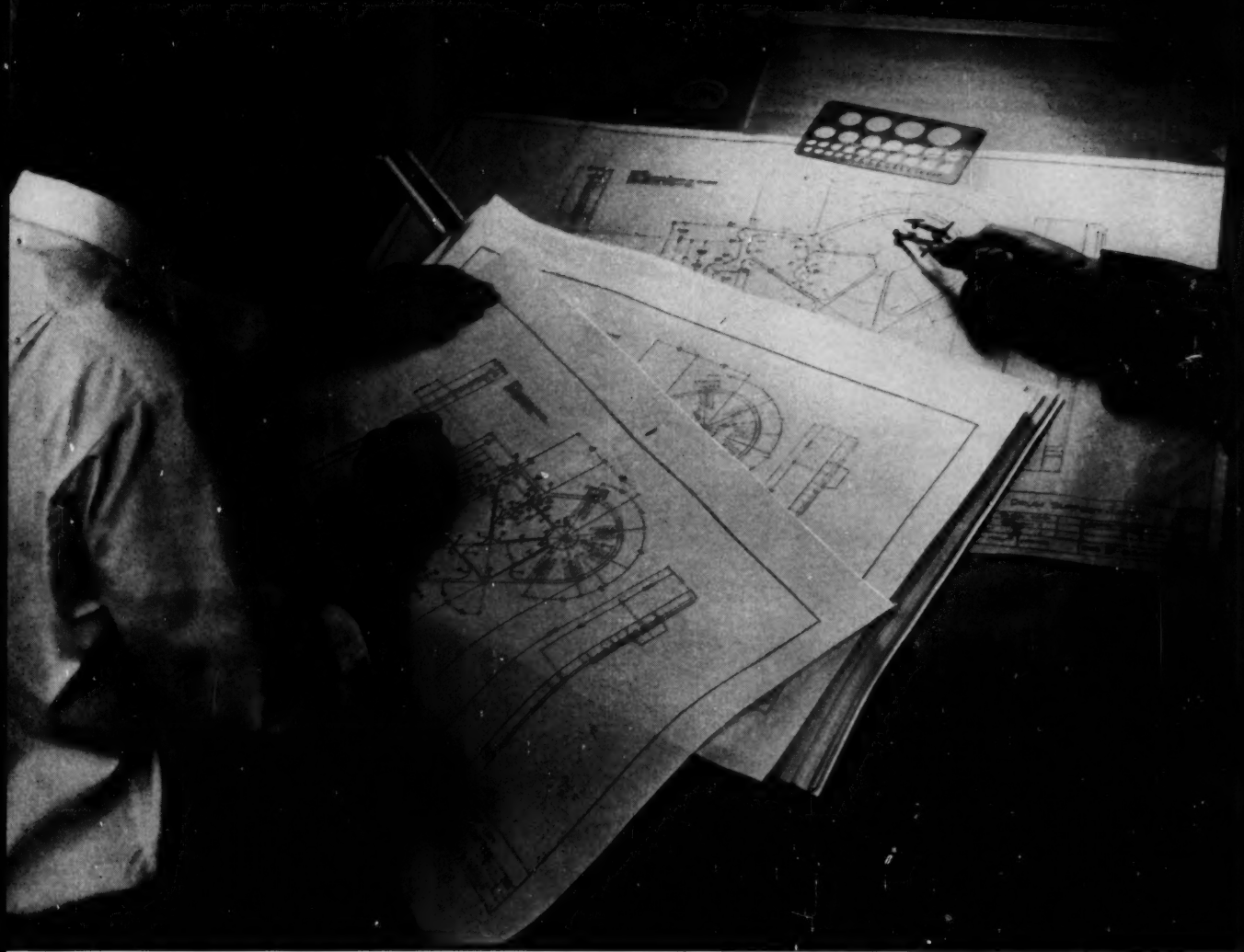
Better alloys often cost no more than the "inexpensive" ones when your part is an investment casting. What counts is *castability*, not machinability.

Write for complete technical and facilities information.

HITCHINER
Milford 2, New Hampshire

Circle 524 on Page 19

XEROGRAPHY for engineering-drawing reproduction...



Top-quality prints on ordinary paper... reduced or size for size ...at a fraction of your present cost

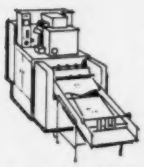
Thousands of the nation's leading firms have already standardized with XeroX® copying equipment. Xerography is the fast, clean, dry, electrostatic process that has literally revolutionized engineering-drawing reproduction. Savings in excess of $500,000 a year have been reported by one large firm. Smaller users report proportionate savings. XeroX equipment is available to you, without capital investment, at modest monthly rentals.

For high-quality offset paper masters:

XeroX Model 1218 copying equipment combines with offset duplicating... and the results are spectacular. This equipment prepares sharp, inexpensive paper masters from original drawings of A to D size. The larger drawings are perfectly reduced to 12″ x 18″ masters, from which multiple prints can be run off in seconds.

Volume reproduction from original drawings or roll microfilm: Just push a button on the XeroX Copyflo® continuous printer for sharp, dry, ready-to-use prints (on ordinary paper, vellum, or offset paper masters up to 12″ wide). Prints are made at the rate of 20 linear feet a minute. Copyflo printers reduce, enlarge, or copy size-to-size from original drawings or roll microfilm (16 or 35mm).

Reproduction from card-mounted microfilm: The XeroX Copyflo 24C and the exciting new Copyflo 1824 automatically produce dry, positive prints on ordinary paper, vellum, or offset paper masters from 35mm card-mounted microfilm. The 24C

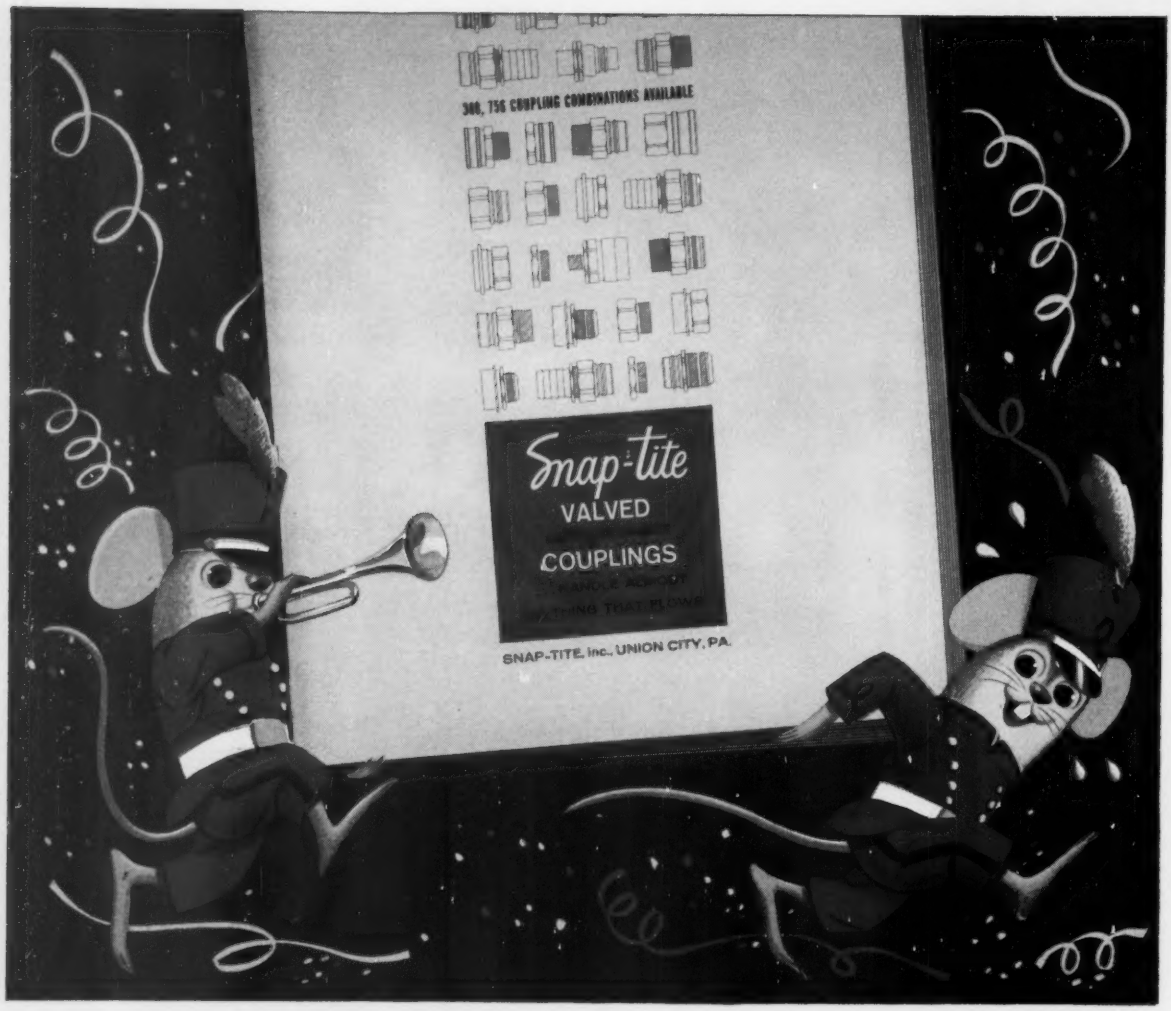


produces ready-to-use prints (up to 24″ x 36″) at the rate of 20 linear feet a minute. The new 1824 for small volume users, or large, decentralized users, produces prints from 8½″ x 11″ to 18″ x 24″.

Get all the facts. Write: Haloid Xerox Inc., 61-170X Haloid Street, Rochester 3, N.Y. Branch offices in principal U.S. and Canadian cities. Overseas: Rank-Xerox Ltd., London.

HALOID XEROX®

Circle 525 on Page 19



announcing—a dynamic new catalog for coupling users

complete specs on 308,756 possible coupling combinations

And it's hot off the press! This comprehensive new 62 page catalog contains complete information on all sizes and types of Snap-Tite quick-connect, quick-disconnect couplings for:

positive pressure applications; impact air tools; high pressure, vacuum and very low pressure; hard-to-handle fluids; no-spray applications; no-spill aircraft and missile applications.

Included are descriptive cutaway and exploded illustrations and complete weight and dimensional data for all sizes, ¼" to 6". Working pressures, flow, pressure drop and spillage data are also provided in detailed graphs and charts.

SPECIAL! RUBBER GASKET USAGE GUIDE SECTION
For the first time in the quick-connect coupling field, a compilation of complete selection data describing packer seals to use in handling over 300 fluids and gases.

Write today on your company letterhead for free copy!

Snap-tite

UNION CITY, PA.

Circle 526 on Page 19

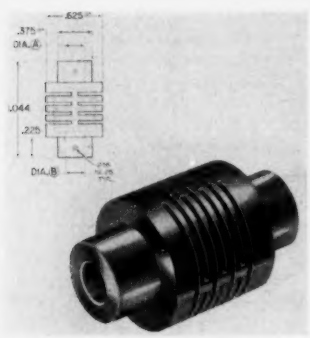
through the metal chassis or terminal block. Both male and female connectors can be crimped or soldered for wiring purposes. Connectors are supplied with white Teflon insulators as standard and are also available in nine colors on a custom basis. **Jupiter Electronics Inc.**, 225 E. 144th St., New York 51, N. Y.

Circle 756 on Page 19

Instrument Coupling

is all-speed, flexible unit

Superprecision instrument coupling has a high degree of accuracy and efficiency. It answers the need for an efficient, precise, all-speed flexible coupling. Absence of moving and



wearing parts assures unusual speed and life expectancy. While permitting linear and angular backlash, coupling allows parallel hub displacement. It also provides extremely close concentricity between both hub bores. **Santa Fe Instruments Inc.**, 2343 Jerome Ave., New York 68, N. Y.

Circle 757 on Page 19

Motor-Pulley Drives

in ratings from 1-15 hp

Adjustable-speed, motor-pulley drives are designed for simple, economical, dependable operation. They are available in ratings of 1-15 hp. Output speeds range from 2200 to 141 rpm with a 3:1 speed variation utilizing 1750 or 1160-rpm motors. Incorporating the efficient power transmission of a V-to-V drive and a simple motor-pulley design, drives provide reliable power transmission combined with maximum

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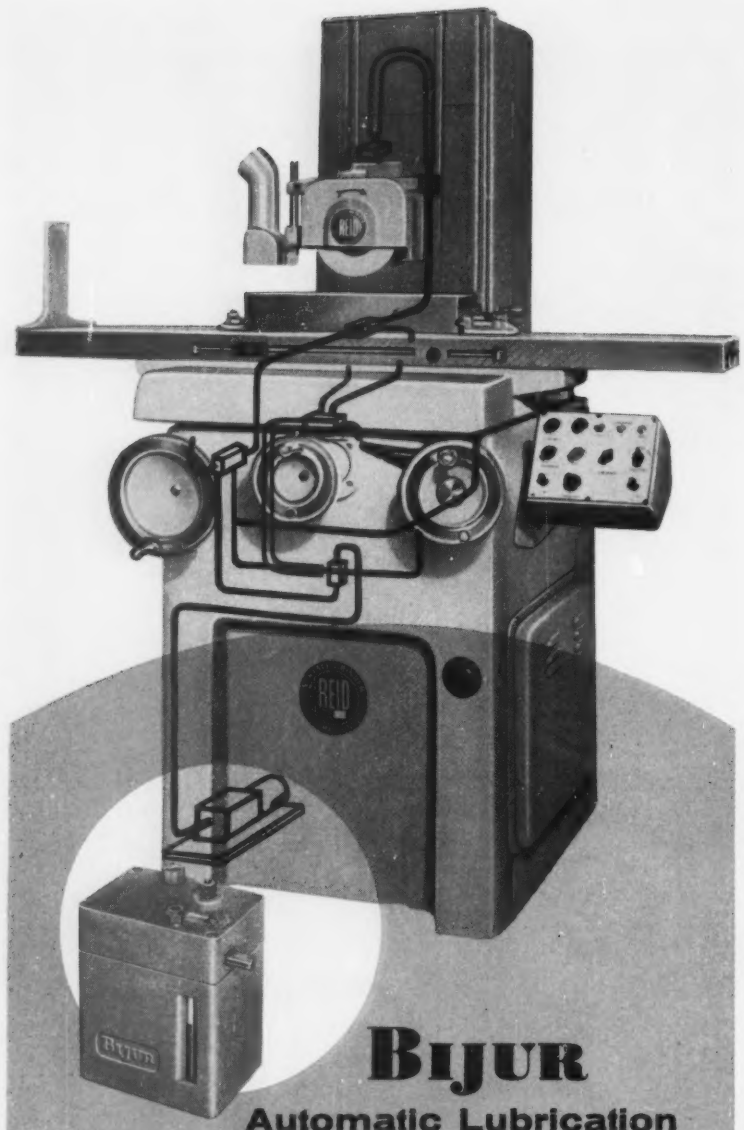
Circle 527 on Page 19



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Your customers can get more production from your machines when they are equipped with Bijur Automatic Lubricating Systems because every bearing is metered the proper quantity of oil at predetermined intervals.

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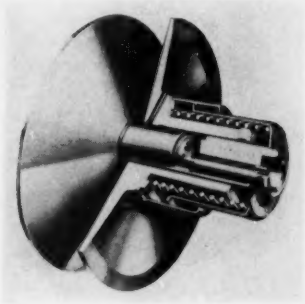


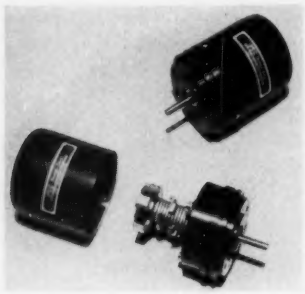
horsepower capacity. Applications include utilization with centrifugal pumps, presses, hoppers and shakers, and food-processing machinery. **Sterling Electric Motors Inc.**, 5401 Telegraph Rd., Los Angeles 22, Calif.

Circle 758 on Page 19

Limit-Stop Assembly

has operational range of 30 to 4530 deg

Improved precision limit-stop assembly, available from stock in a 3/16-in. shaft size, is available in ball or oilless-bronze bearing types. Self-contained in a black anodized case, 1¾ in. in diam, unit is readily adjusted by the setting of a series of washers, each governing 300 deg of rotation. Unit provides fully adjustable rotational limit control within an operational range of 30



to 4530 deg. **PIC Design Corp.**, 477 Atlantic Ave., East Rockaway, L. I., N. Y.

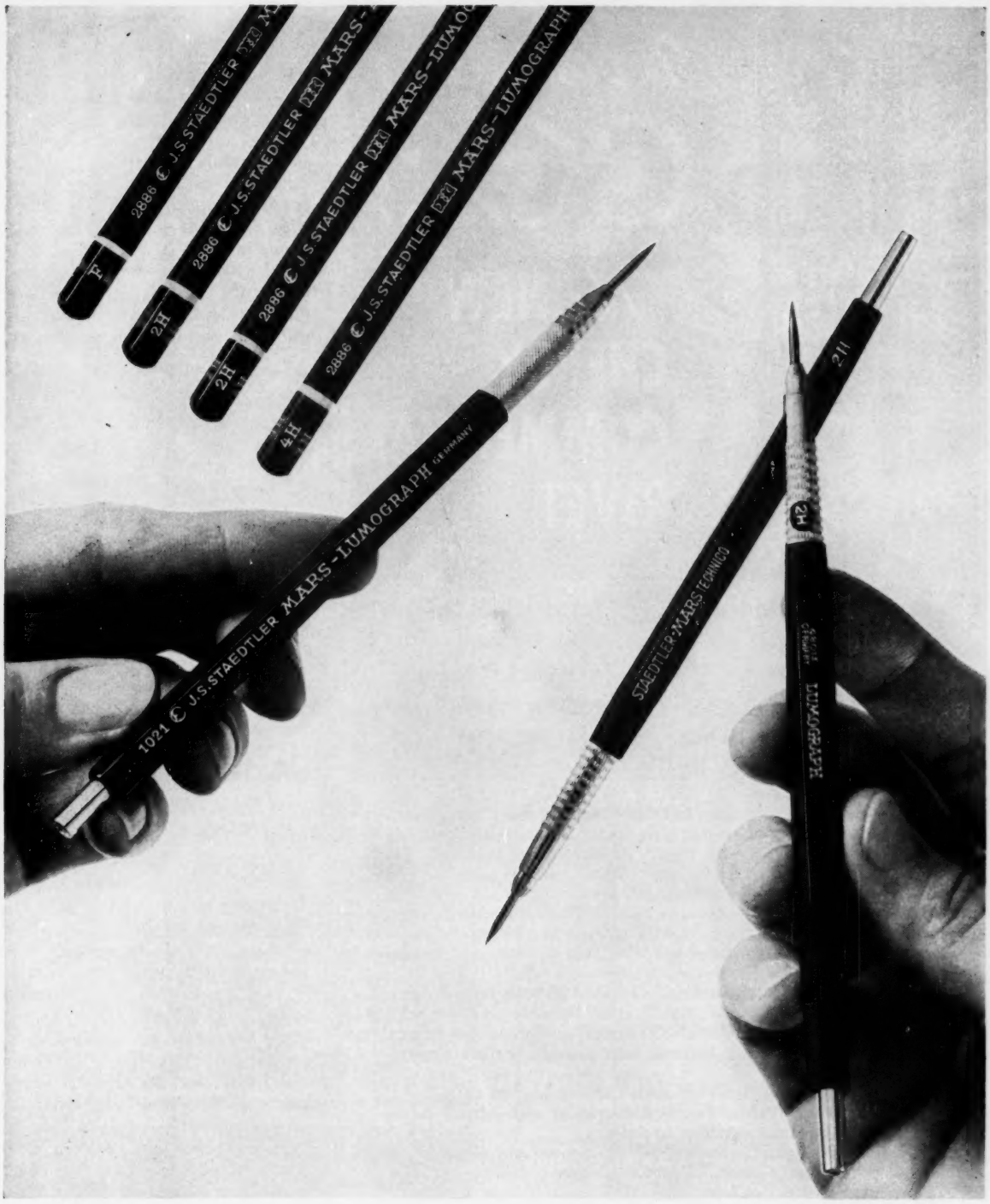
Circle 759 on Page 19

Precision Tachometer

has high output in only 3½ in. length

Model SU-78OD-1 precision tachometer is a 45-v, 1000-rpm unit particularly applicable for indus-

Circle 528 on Page 19



MARS vs MARS — You need neither lawyer nor judge. Let your own preference decide in favor of one MARS over another. For whether you pick one of the wood-cased Lumographs or one of the Technicos you'll be using the very finest.

Among the famous imported Mars drafting products are: the Mars-Technico push-button lead holders (with adjustable degree indicator*, with specific degree imprint*, the economy model*); Mars-Lumograph drawing leads, 18 degrees, EXB to 9H; Mars-Lumograph drawing pencils*, 19 degrees, EXEXB to 9H; Mars-Duralar pencils and leads for drafting on Mylar®-base drafting film —5 special degrees, K1 to K5; Mars-Duralar Technicos with adjustable Duralar degree indicator; Mars-Lumochrom colored drawing pencils, 24 shades. Also: Mars Pocket-Technico for field use; Mars pencil and lead sharpeners; Mars Non-Print pencils and leads; Mars-Duralar erasers. Mars products are available at better engineering and drafting material suppliers everywhere.

® T.M. for duPONT's Polyester film. *Shown.

the pencil that's as good as it looks **MARS**

J.S. STAEDTLER, INC.
HACKENSACK, NEW JERSEY

- Large Manufactured Head
- Oversize Blind Head
- Plugged or Hollow
- No Stem Trimming
- Minimum Blind-Side Clearance
- Excellent Head Seating
- Wide Grip Range
- Full Range of Diameters
- Positive Hole Fill
- Easy Installation

For fast, secure, more economical fastening, the new Cherry Commercial Rivet is a blind fastener ideal for production manufacturing and repair. Installed by one man from one side of the work, the Cherry Commercial Rivet reduces cost of assembly, repair and maintenance in both blind and open applications.

Minimum blind side clearance, adaptability to variations in material thickness, and positive hole fill even in oversize or out-of-round holes offer advantages not available in other production fasteners.

Cherry Commercial Rivets are available in both hollow (non-structural) and plugged (structural) types. The plugged rivets have strength values comparable to solid rivets, and stems fracture to eliminate all trimming operations and provide further production economy.

Grip lengths from 1/2" to 1" inclusive, and diameters of 3/8", 5/32", 5/16" and 1/4" are provided in either universal or countersunk head. Special rivets are manufactured to order.

For full technical information on the new Cherry Commercial Rivet, write Cherry Rivet Division, Townsend Company, Box 2157-E, Santa Ana, California.

Aluminum Mild Steel Monel

CHERRY RIVET DIVISION

SANTA ANA, CALIFORNIA

Townsend Company

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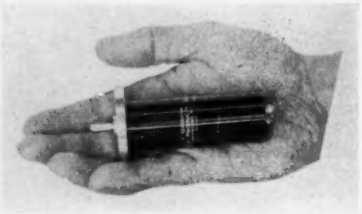
In Canada: Parmenter & Bulloch Manufacturing Company, Limited, Gananoque, Ontario

trial applications that require minimum size and weight without sacrifice of reliability or service life. In spite of an approximate over-all body length of only 3½ in., it achieves high output by increased armature length. Unit is supplied with a stainless-steel shaft having a diameter of 3/16 in. and a convenient flange for ease of mounting. Outer shaft bearing is fitted with a Neoprene seal to prevent the entrance of contaminants usually associated with industrial applications. Cover completely encloses output terminals, affording protection against possible external shorts. **Servo-Tek Products Co.**, 1086 Goffle Rd., Hawthorne, N. J.



Circle 760 on Page 19

Split-Clamp Connectors

for liquids and gases to pressures of 150 psi

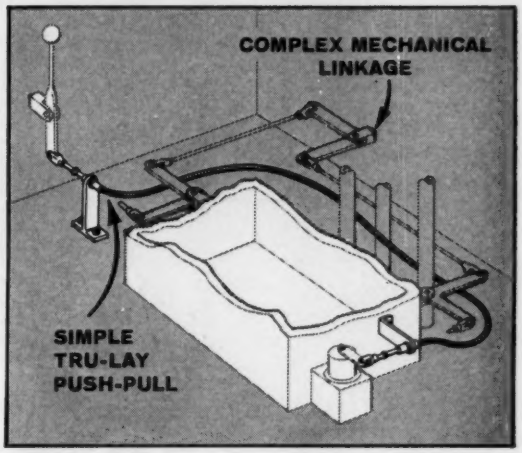
No. 8370 Split-Eyelet connectors are easily and quickly installed to continuing or uncut pipe or tube of 1¼, 1½, and 2-in. size. Connectors are used in place of reducer tees, and to connect such parts as spray nozzles, gages, and hose nozzles. Split-clamp is cadmium-plated, heavy-gage steel or stainless steel. Bodies provide a ½-in. NPT female outlet and are brass or stainless steel. Connectors are mounted by drilling an 1 1/8-in. diam hole in pipe or tubing and placing connector in position. Twin-bolt compression of clamp in combination

Circle 530 on Page 19

ACCURATE REMOTE CONTROL FOR HUNDREDS OF PRODUCTS

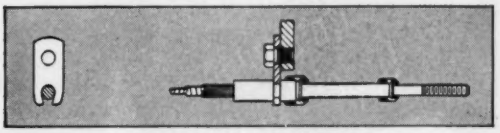
— — with Tru-Lay *PUSH*-PULL Controls

If your products involve remote control—electrical, hydraulic, pneumatic or direct—TRU-LAY PUSH-PULL FLEXIBLE CONTROLS can help solve your design problems. They provide positive remote control over short or long distances—up to 150 feet from the control point. Because they operate while flexing, they can snake around obstructions. They will not buckle. They are ruggedly constructed, easily installed and operated, sealed against dirt and moisture, and will handle jobs with as much as 1,000 lbs. input. PUSH-PULL CONTROLS are simple, have but one moving part, are noiseless and give a lifetime of accuracy. Mechanical linkages, on the other hand, are complex. Unlike PUSH-PULL CONTROLS, they are made of many parts, wear at many points, and produce increased backlash, vibration rattles and lost accuracy.

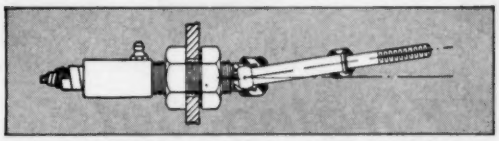


THESE FEATURES HELP SOLVE DESIGN PROBLEMS

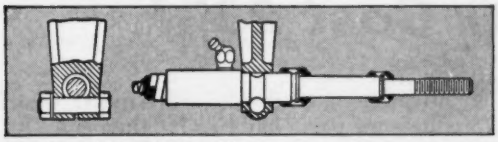
Anchorages



Clip anchorage • a simple clip for light loads

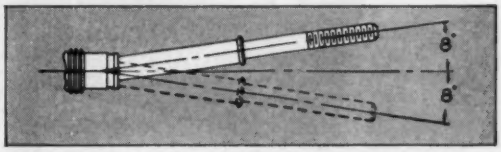


Bulkhead anchorage • for heavy-duty installations



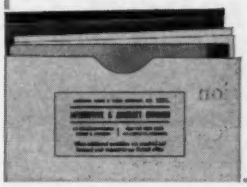
Machined bracket anchorage • can be furnished for mounting any PUSH-PULL cable at the swivel terminal

Swivel Action



Standard assemblies have end fittings with a swivel movement of ± 8° to compensate for misalignment and rise or fall of lever arms. Swivel joints, and the sliding ends, are sealed against dirt and moisture.

PUSH-PULL DATA FILE SHOWS HOW TO SIMPLIFY, IMPROVE DESIGN



• Write for your PUSH-PULL Data File. It contains a complete set of engineering bulletins which describe in detail the operation of PUSH-PULL CONTROLS, their applications, features and advantages.

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Circle 531 on Page 19

Champion Upset Forging Cuts Finished Gear Cost 23%!

The manufacturer of this pinion gear cuts finished cost 23% by starting with Champion upset forged blanks. He saves on material by using a $1\frac{1}{64}$" x 5" blank with a $1\frac{3}{4}$" collar instead of $1\frac{3}{4}$" bar stock. He saves again because most rough machining is eliminated.

Upset forgings can save you money and give you better quality too . . . upsetting increases strength by directioning grain flow in the metal. Check your products for parts like this . . . then call —

THE CHAMPION RIVET COMPANY
T. P. Champion, President
CLEVELAND 5, OHIO • EAST CHICAGO, INDIANA

When it's a vital part, better make it **FORGED**

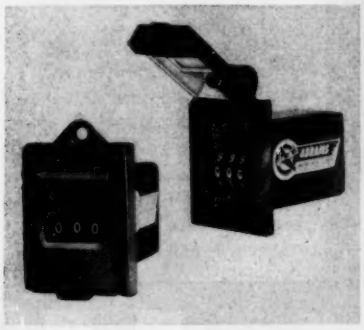
with Buna-N gasket provides a leakproof seal. Connectors are used for liquids and gases to pressures of 150 psi. **Spraying Systems Co.**, 3274 Randolph St., Bellwood, Ill.

Circle 761 on Page 19

Miniature Counter

for use in adverse lighting conditions

Model CE-L miniature, magnetic, three-figure counter is available in either additive or subtractive version, and for 6, 12, 24, and 100 v dc. It has a small light in the cover to illuminate the counter wheels, affording easy reading of the counter



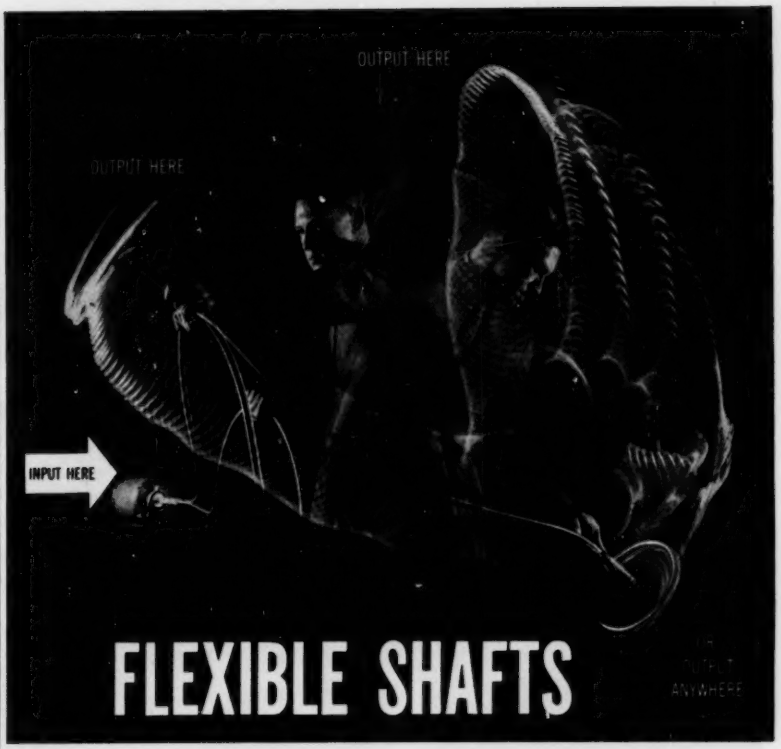
in adverse lighting conditions. Actuated electromagnetically, unit records up to 20 pulses per second. It can be used in temperatures from −65 to +160 F. **Abrams Instrument Corp.**, 606 E. Shiawassee St., Lansing 1, Mich.

Circle 762 on Page 19

Snap-Action Switch

features new hinged-lever actuator

Series E13-OOH snap-action switch is used for appliance, vending, electronic devices, and other applications requiring precision electrical control. Switch features low-operating-force, hinged-lever actuator. Terminals accept standard quick-connect or solder wiring connections. Switch is supplied normally open or normally closed in SPST or SPDT models. Self-lubricating nylon button and switch mechanism of basic switch models provide long life and precise operating point with 0.187 in. overtravel with standard lever. Variations in operating force and



put power where you want it

Flexible shafts give the designer important new freedom in transmitting rotary power or control between two points. They enable you to position your power source and your driven part to best advantage . . . without worrying about obstructions, vibration, shock or alignment.

Even if the components are in relative motion to each other, you can still transmit power smoothly and economically.

Flexible shafts also reduce manufacturing costs . . . use fewer parts . . . eliminate cumbersome gears, drives, couplings, universals. With rigid connections gone, alignment and tolerance problems fade away, and installation is a snap.

Whatever your rotary transmission problem, there is a good chance that one of S. S. White's flexible shaft lines can solve it . . . *Standard, Pre-Engineered,* or *Custom-Designed* flexible shafts.

S. S. WHITE INDUSTRIAL DIVISION,
DEPT. 4, 10 East 40th Street, N. Y. 17, N. Y.

THE S. S. WHITE FLEXIBLE SHAFT HANDBOOK
New 4th Edition . . . Send for your free copy!

1158

S.S.White
FIRST NAME
IN FLEXIBLE SHAFTS

Circle 533 on Page 19

SAVE SPACE, SAVE WEIGHT, SAVE MONEY!

Dyna V

There's a *difference*, as you can see! The 10-groove D-section sheave in the foreground is replaced with the narrow 8-groove 5-V Dyna-V sheave on the line shaft. *Same power*, in a far more compact installation, with a $477 difference in price. And big future savings in belt replacement costs!

Everyone is going Dyna-V! Thousands of installations reveal that Dyna-V performance is *even better* than promised when we first introduced this new compact drive. In medium and high horsepower ranges, savings go as high as 30%!

Dyna-V can handle 3 times as much power in the same space. Dyna-V Sheaves decrease shaft overhang, increase bearing life. And Dyna-V Belts possess *all* premium qualities. Conditions requiring static conductivity or resistance to oil, moisture and heat are met by Dyna-V's one grade—the finest. Ask your Dodge Distributor, or write us for complete drive bulletin. Dyna-V Drives are available for capacities from 1 to 1500 hp.

Dodge Manufacturing Corporation, 3300 Union St., Mishawaka, Ind.

The Products with the Pluses...

DODGE

of Mishawaka, Ind.

CALL THE TRANSMISSIONEER, your local Dodge Distributor. Factory trained by Dodge he can give you valuable assistance on new cost-saving methods.

other characteristics can be supplied. Basic switch is also available with pushbutton, spring-leaf, and standard button actuators. **Cherry Electrical Products Corp.**, West Deerfield Rd., Highland Park, Ill.

Circle 763 on Page 19

Vinyl-To-Metal Adhesives

are available in four types

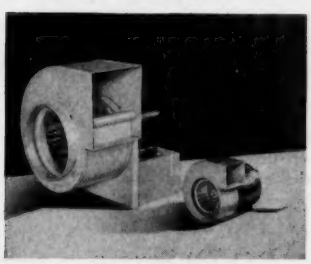
Vy-Metal adhesives bond vinyl films that simulate leather, textiles, wood grains, and marble to steel, aluminum, and magnesium metals. Line includes four types: Curing adhesive with heat resistance and hardness that can be controlled by varying curing time and temperature; a simple-to-use, thermoplastic adhesive; a heat-resistant adhesive for very deep draws which allows stress distribution; and a thermosetting adhesive that offers unusual heat resistance along with excellent adhesion and good deep-drawing properties. All bond vinyl to metal firmly enough to tear the film upon separation. **National Starch & Chemical Corp.**, 750 Third Ave., New York 17, N. Y.

Circle 764 on Page 19

Centrifugal Fans

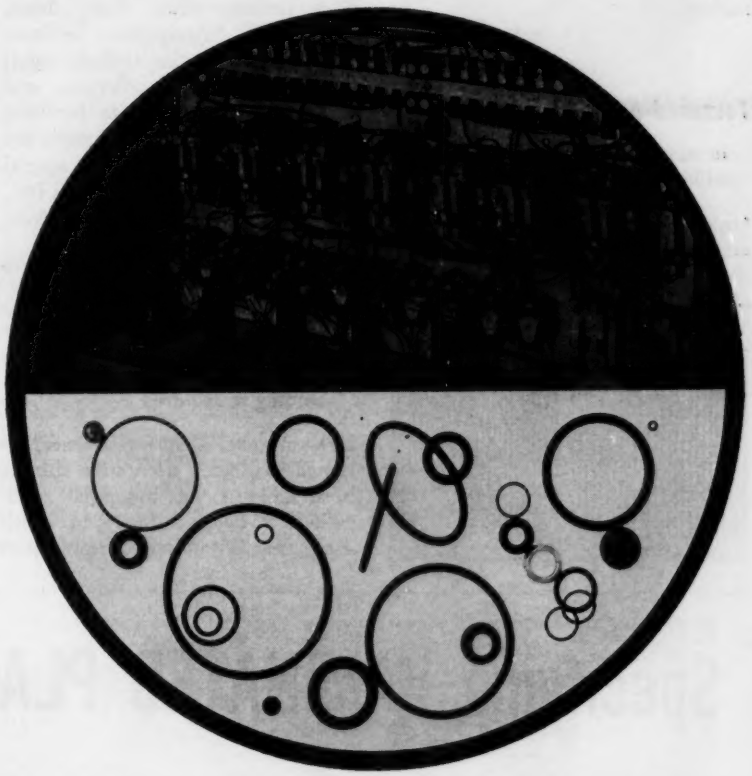
have air deliveries from 45 to 325 cfm

Compact, single-inlet, single-wheel centrifugal fans are available for cooling and pressurizing requirements in the electronic and control fields. With scroll widths ranging



PARCO PROBLEM PROBERS

???...HIGHEST QUALITY IN HUNDREDS OF THOUSANDS DAILY



!!! If production of your product design requires thousands of highest quality molded rubber parts every day, Parco's Parco-Matic Process is the answer. Parco's new, electronically controlled high-speed technique for producing molded rubber parts excells in maintaining constant high quality at the lowest possible cost. ○ The Parco-Matic Process employs extremely accurate molds in which each unit is produced by an electronically controlled curing cycle employing exactly duplicated time and temperature constants from batch to batch. Because of mold accuracy, the products produced are essentially flashless and maintain consistent close tolerances. The last part molded in a long production run is an exact duplicate of the first and all parts in between when Parco-Matic is used. ○ There is no room for error or variations with Parco-Matic. If you require large quantities of the highest quality molded rubber parts combined with production economies, let Parco-Matic solve your problem and reduce your costs.

Send for your latest Parco Slide Rule

Plastic and Rubber Products Company
2100 Hyde Park Boulevard
Los Angeles 47, California

Plastic and Rubber Products Company
2100 Hyde Park Blvd. • Los Angeles 47, Calif.
Please send the Parco O-Ring Data Chart to:

NAME_____
COMPANY_____
BUSINESS ADDRESS_____
CITY_____
ZONE____ STATE_____

Circle 535 on Page 19

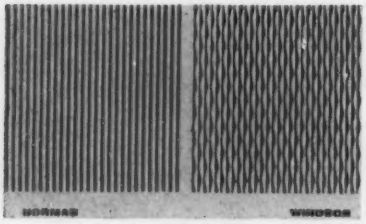
from 3⅞ to 9¼ in., small units have air deliveries from 45 to 325 cfm over a wide pressure range. Variety of special mounting brackets and filter cabinets is available to simplify the adaption of these units to custom cabinet needs. **Propellair Div., Robbins & Myers Inc.**, Springfield, Ohio.

Circle 765 on Page 19

Textured Metals

in new pattern and wider widths

Unique characteristic of new Norman texture (left) is its ability to change the dimensional appearance of a product. Low units look taller, and narrow areas look wider and more spacious. Available in all metals and a variety of standard and special finishes, Norman texture is available in widths to 12 in., any length, in sheet, strip, or coil. Average depth of the texture is 0.010 in. Windsor texture (right) is now available in width to 36 in. with an average pattern depth of 0.007 in. Both textures resist mars, dents, scuffs, and fingerprints. Intrinsic functional properties include rigidity, controlled light reflection, and increased surface area to facilitate heat dissipation. Both textures are available in standard and special perforations. **Ardmore Products Inc.**, 191 Aldene Road & First Ave., Roselle, N. J.

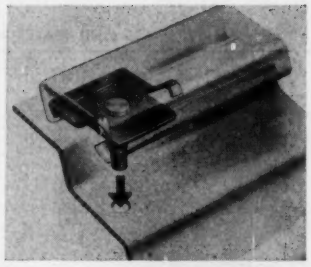


Circle 766 on Page 19

Spring Fastener

for use where a molding is required

Low-carbon-steel spring fastener, designed to hold a decorative chrome hood molding, has industrial applications in every industry in which a molding is required. The two-part



fastener is formed with two integrated points of contact. Dimpled spring legs permit easy, secure positioning of clip within molding. Embossed fastener panel section provides strength without being weakened when entire unit is tightly bolted. **George K. Garrett Co., Inc.**, Torresdale Avenue & Tolbut Street, Philadelphia 36, Pa.

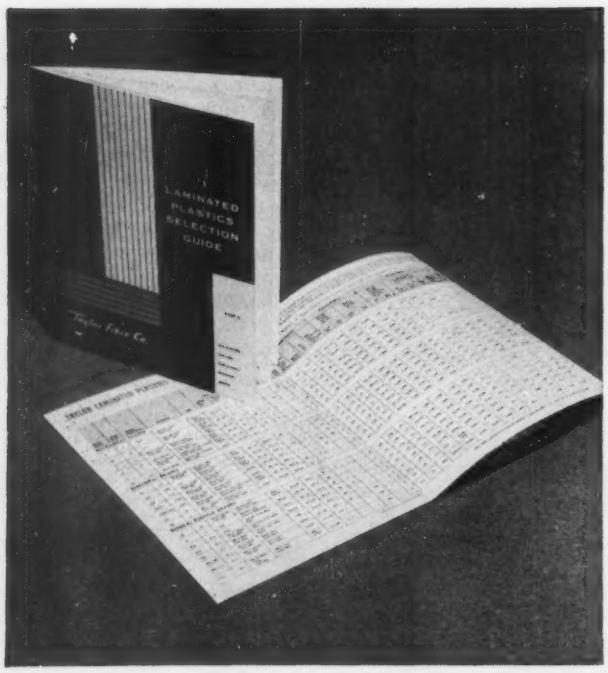
Circle 767 on Page 19

Synthetic Rubber

has good mold flow characteristics

Styrene-butadiene synthetic rubber, Plioflex 1510, has light color and excellent physical properties. Stabilized with a nonstaining, nondis-

Specifying LAMINATED PLASTICS...as sheet,



Use this Taylor Selection Guide to make selections of the Taylor laminated plastics that will fit your requirements.

TAYLOR FIBRE CO. BELONGS IN YOUR SPECIFICATIONS

Taylor has the products:.. offers more than 50 grades of industrial laminated plastics . . . including paper, cotton cloth, nylon, asbestos, glass cloth, or other base material impregnated with phenolic, melamine, silicone or epoxy resins and formed into sheets, rods and tubes under heat and pressure. Also a number of composite materials, including copper-clad laminated plastics, vulcanized fibre and laminated plastics, rubber and laminated plastics, asbestos and laminated plastics, and aluminum and laminated plastics.

coloring antioxidant, material has low viscosity, giving it easy processing and good mold flow characteristics. Excellent color suggests use of material in closed-cell sponge-rubber products, flooring, sporting, household, and related goods that require high color standards. Material also exhibits excellent physical properties when compounded, a feature normally not associated with a low-viscosity rubber. **Chemical Div., Goodyear Tire & Rubber Co.**, Akron 16, Ohio.

Circle 768 on Page 19

Servo Motor

miniature unit is available in various shaft configurations

J126-06 Size 5 miniature servo motor is a high-torque, low-inertia, lightweight unit. Only ½-in. in diam and 0.968 in. long, it is designed for use in servo systems where instant response is a requirement. Motor is available in a variety of shaft configurations. Operating temperature range is −54 to +125 C. **Kearfott Div., General Precision Inc.**, 1150 McBride Ave., Little Falls, N. J.

Circle 769 on Page 19

Tube Fitting

incorporates a captive ferrule

Modified Intru-lok tube fitting consists of body, nut, and ferrule. It is especially suitable for instrumentation, pilot, air, water, lubricant, or coolant lines of copper, aluminum, Parker-POL, or other plastic tubing. Elongation and dimpling of the ferrule make it a "snap-in" unit, held captive by the nut. It can be pushed in or out with the fingers, but will not drop out. Captive ferrule makes the fitting in effect a two-piece unit. Larger opening in the new nut, to accommodate the longer ferrule, gives the nut sufficient clearance to slip easily around bends in the tubing. **Parker Fittings & Hose Div., Parker-Hannifin Corp.**, 17325 Euclid Ave., Cleveland 12, Ohio.

Circle 770 on Page 19

Adjustable-Speed Pulleys

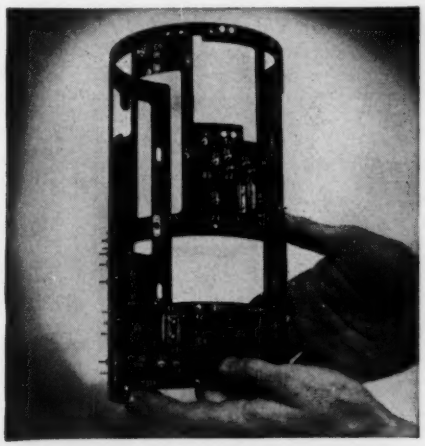
provide instantly variable ratios to 3:1

Adjustable-speed pulleys are rated at 20 to 25 hp at 1750 rpm and 10 to 15 hp at 1150 rpm. They provide instantly variable ratios to 3:1.

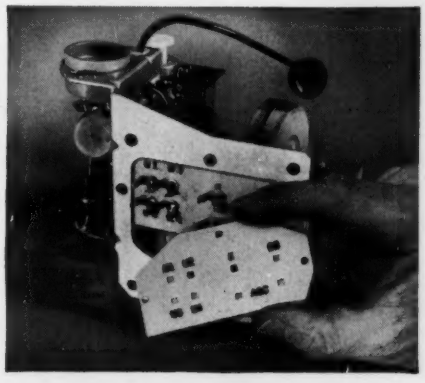
rod, tube or fabricated parts?

Taylor has the facilities. Its Norristown, Pa., plant, comprising some 300,000 sq. ft., produces both laminated plastics and vulcanized fibre . . . is one of the most completely integrated in the industry . . . even makes its own paper and a large percentage of its own resins. The La Verne, Calif., plant, with over 45,000 sq. ft. of floor space, specializes in the manufacture of laminated plastics for the convenience of West Coast customers. And both plants can fabricate parts from any Taylor materials to specifications, economically.

Taylor laminates offer many advantages over metals. They have a higher strength-to-weight ratio, are corrosion resistant, and can be fabricated more easily. This Taylor Selection Guide will help you evaluate the different grades available. Write for your copy today. Taylor Fibre Co., Norristown 47, Pa.



For applications requiring high strength retention at elevated temperatures, Taylor Grade GEC—an epoxy resin, glass fabric base material.

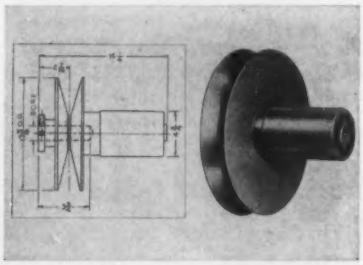


For high-temperature electrical applications and high-frequency radio equipment, Taylor Grade GSC—a silicone resin, glass fabric base material. Has high heat resistance, excellent electrical properties, and high arc resistance. Will not support combustion.

Taylor
LAMINATED PLASTICS VULCANIZED FIBRE

Circle 536 on Page 19

Known as No. 320 and 325, they use a 2¾-in. top width variable-speed belt, and can be used with a number of NEMA frames. Standard bores are 1¼, 1⅜, 1⅝, and 1⅞ in., with 3¾-in. bore length. Motor travel for full range is 6¾ in. Maximum pitch diameter is 13.1 in. and minimum is 4.35 in. Curved faces maintain full belt contact at all speeds and pitch diameters. Each pulley face is independently actuated by its own



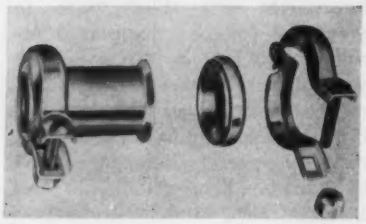
spring, assuring equal, simultaneous movement of both halves to maintain constant belt alignment. Pulleys are dynamically balanced to 0.02 oz-in. for quiet operation and troublefree service. Alemite fittings provide positive lubrication. **Lovejoy Flexible Coupling Co.**, 4882 W. Lake St., Chicago, Ill.

Circle 771 on Page 19

Pipe Coupling

absorbs pipe vibration and is corrosion resistant

Flexmaster pipe coupling is now available in an improved design and in a wider range of standard pipe sizes from ⅜ to 4 in. in lengths from 2 through 36 in. Gasket is fully contained in the gasket retainer to assure uniform pressure of the gasket against the pipe and sleeve. There can be no extrusion of the gasket in any area. Redesign of the coupling ends has increased band tension load to provide a stronger joint. New elbows, crosses, and tees are also available. Joints are supplied in either cadmium-plated steel or with a black painted finish. Coupling absorbs pipe vibration and shock, and is corrosion resistant. It allows up to 4 deg angular misalignment and permits both angular and axial pipe movement without leakage.



Unit fastens with only one nut and bolt on each coupling end, making it particularly suited for quick-breakaway connections. It meets ASA requirements for 150-lb service with temperatures from −40 to +250 F. **Marman Div., Aeroquip Corp.**, 11214 Exposition Blvd., Los Angeles 64, Calif.

Circle 772 on Page 19

Insulation Sleeving

is printed to provide permanent identification

Shur-Codes printed insulation sleeving is available in a complete range of standard and special materials for low to high-temperature applications. Sleeving is slipped over wires, cables, and harnesses for permanent identification. Preprinted to specifications on one, two, or more places around tubing, insulation sleeving is available in many diameters and precut lengths. Materials resist fluids and chemicals. Heat-reactive tubing is supplied in expanded form; with the application of heat sleeve it shrinks to a tight fit of predetermined size. **Westline Products Div., Western Lithograph Co.**, P. O. Box 2980 Terminal Annex, Los Angeles 54, Calif.

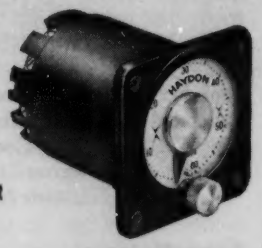
Circle 773 on Page 19

Transparent Bowls

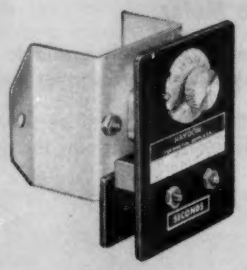
for filters and lubricators need no guards or reinforcement

Unbreakable, transparent bowls for air-line filters and lubricators offer superior resistance to solvents, oils, or corrosive gases. Because of shat-

Other
HAYDON
"Job Proven" Time Controls



ACROTIMER



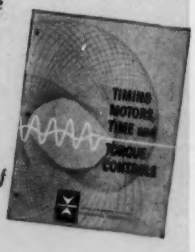
DA-11

New "do-it-yourself" Acrotimer provides time delay or interval timing, opening or closing one or more switches after an adjustable period of time. Modular construction imparts versatility to meet a wide range of operation and design requirements. One basic unit plus easily assembled standard parts provides 12 design variations. Operates at 120 to 240 vac, 50 or 60 cps. Adjustable time ranges from 6 seconds to 24 hours available.

Series DA Time Delay Timer provides time delay or interval timing for applications such as protection of power tubes, or timing portions of a complete cycle of operations. Operates at 120 or 240 vac, 50 or 60 cycles. Switch capable of handling small fractional horsepower motors and components. Four models provide time ranges up to a maximum of 9.5 minutes.

CATALOG: ***Time and Torque Controls***

This 8-page catalog illustrates representative models of timing controls designed and produced by Haydon Division of General Time Corporation. Six types of electric timing motors and a dozen varieties of time and torque controls are shown with operating data and specifications. For more information on how Haydon can serve your time control requirements, write to the address below and ask for your free copy of Catalog No. G-1328.



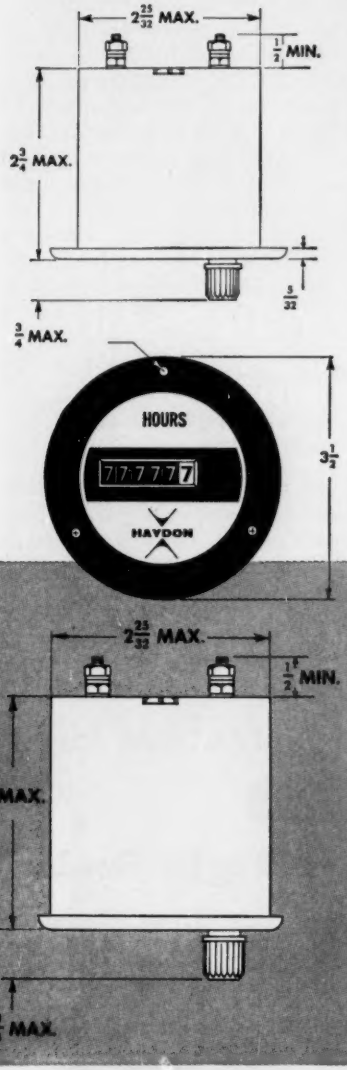
HAYDON

DIVISION OF GENERAL TIME CORPORATION

3126 East Elm Street
Torrington, Connecticut

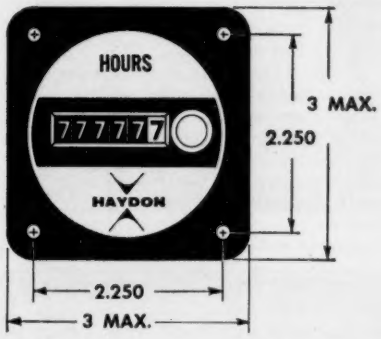
TIME & TORQUE CONTROL

New Series EN and ER Commercial ELAPSED TIME INDICATOR



Ideal for use on machine tools and other industrial or commercial machines and equipment where an accurate record of operating time is required—for efficient preventive maintenance procedures, for rental-basis operation, or for substantiation of manufacturers' guarantees. High-styled face registers hours and tenths and minutes and tenths up to 99,999.9 in big, easy-to-see figures on a direct-reading dial . . . and offers you highest quality and reliability, compactness and light weight at a lower price than comparable units. Available in resettable and non-resettable models with 3½" round bezel or 3" x 3" square bezel. Designed

for operation at 120 or 240 vac, 50 or 60 cps. Low input: 5.0 watts at 60 cps, 3.4 watts at 50 cps. Write today for complete information and engineering data: Haydon Division of General Time Corporation, 3126 East Elm Street, Torrington, Conn.



TIMING MOTORS
TIME AND TORQUE CONTROLS

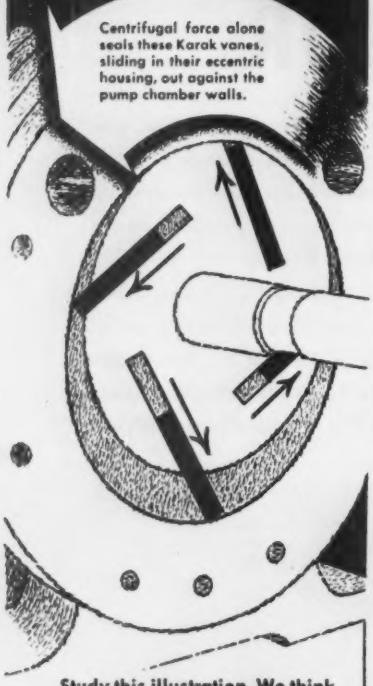
HAYDON

DIVISION OF GENERAL TIME CORPORATION

3126 EAST ELM STREET
TORRINGTON, CONNECTICUT

Circle 537 on Page 19

ONE PICTURE WORTH A THOUSAND JOBS!


Centrifugal force alone seals these Karak vanes, sliding in their eccentric housing, out against the pump chamber walls.

Study this illustration. We think you must agree that our Karak W126 vane in this M-D Dry Air Pump displays a rare, wide combination of valuable qualities in one of the toughest of all carbon-graphite applications.

1. **Low Friction**
2. **Self-Lubricating**
3. **Non-Sticking**
4. **Hard but Light**
5. **Chemically Inert**
6. **Non-Contaminating**
7. **High Shear Resistance**
8. **Dimensional Stability**
9. **Non-Warping**
10. **Machining Tolerance: .0005"**

We can find or create the unique Karak compound for your "impossible" application! Send for free Karak Brochure No. 1164A.

The OHIO CARBON COMPANY
12508 BEREA ROAD,
Dept. 281, CLEVELAND 11, OHIO

Circle 538 on Page 19

terproof qualities, bowls completely eliminate need for bowl guards or wire reinforcement, yet are clearly transparent to permit visual inspection. Recommended maximum operating conditions for the bowls are 250 psi at temperatures to 200 F, and 200 psi at temperatures reaching 250 F. **C. A. Norgren Co.**, 3400 S. Elati, Englewood, Colo.

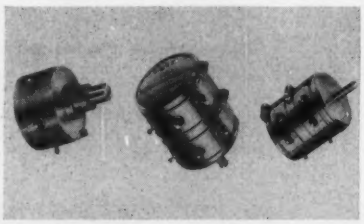
Circle 774 on Page 19

Precision Potentiometers

have thin-film metallic resistance element

For use where small increments of shaft rotation must produce proportionally small changes in resistance, deposited-film precision potentiometers provide resolution of better than 0.01 per cent. Thin-film metallic resistance element of extremely fine granularity is capable of being resolved into very small changes in resistance. Potentiometers exhibit excellent wear and rotational life under conditions of high ambient temperature and severe vibration and shock. Potentiometers shown, measuring only $1\frac{1}{16}$ in. diam, meet rigorous environmental specifications for airborne and space equipment. They are available in single or ganged types with shaft and housing features adaptable for servo or panel-mounted applications. **Mechatrol Div., Servomechanisms/Inc.**, 1200 Prospect Ave., Westbury, L. I., N. Y.

Circle 775 on Page 19



Mylar Jackets

insulate a variety of electrical, electronic parts

New insulating jackets are Mylar film laminated to polyethylene, which permits them to be shrunk or expanded without breaking down

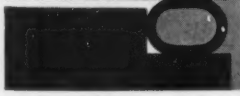
ringside view of United's **exclusive feature** for

Pressure Tight Seals

United's exclusive, patented* self-energized metallic O-rings are circular tubes vented by tiny holes drilled in the ring wall. The holes are to balance the interior and exterior pressures in order that the ring may respond to variation in deflection of the sealing surfaces with a natural resilience uninhibited by the external pressure.

In metal-to-metal applications, self-energized metallic O-rings are capable of forming positive, permanent, non-corrosive static seals under extreme temperatures from −321°F. to 1800°F., and under pressures equal to ultimate compression stress of the metal itself. Available in various metals and finishes (including Teflon* and silver coatings,) 3/8" dia. to any size or configuration. United also makes non-vented and pressure-filled O-rings. Write for free 22-page booklet.

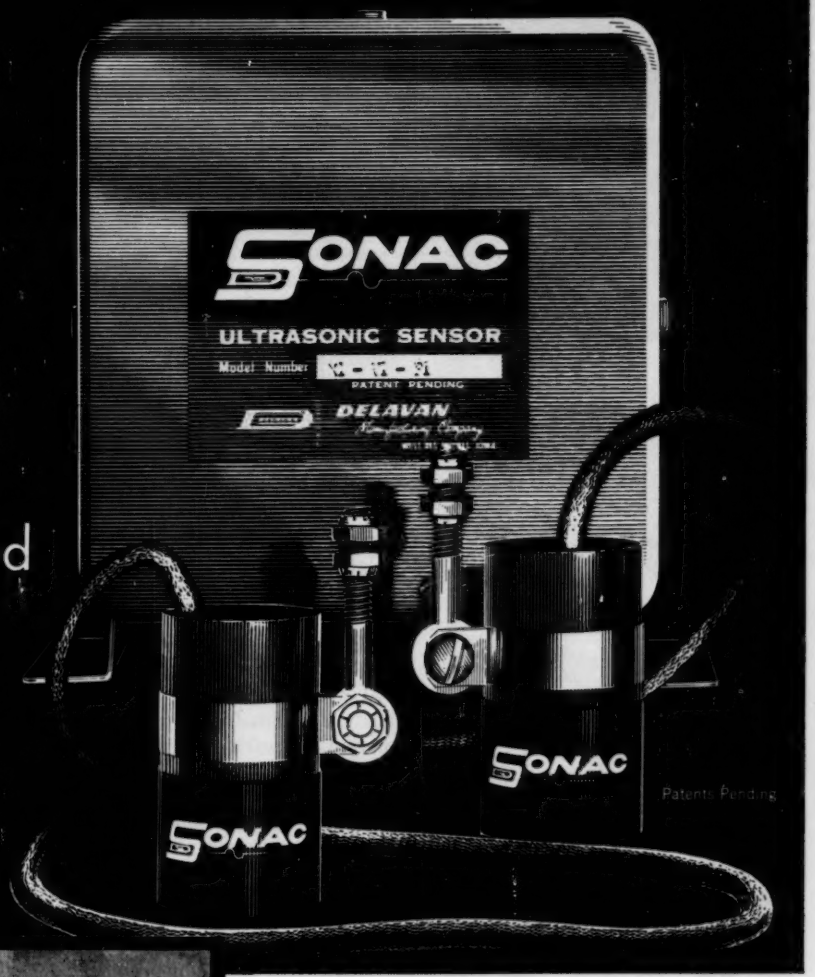
**Registered trademark for DuPont Tetrafluoroethylene resins.* PATENTS 2,809,269; *2,837,360

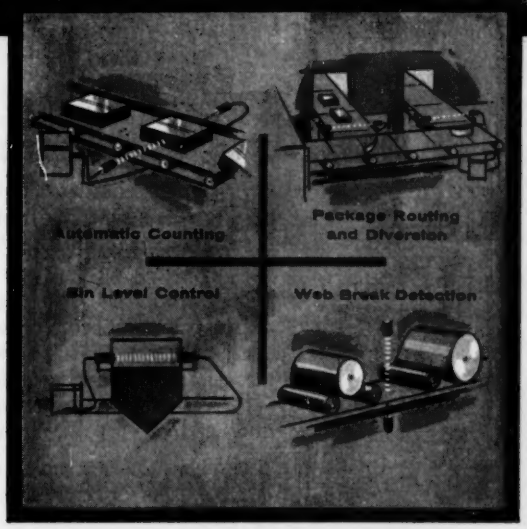


UNITED METALLIC "O" RINGS
manufactured by
United Aircraft Products, Inc.
Box 1035 • Dayton, Ohio

Circle 539 on Page 19

a new dimension in automated controls





SONAC ULTRASONIC,

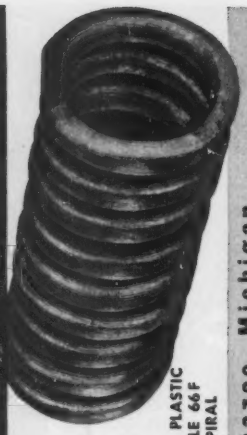
NON-CONTACT SENSING AND SWITCHING SYSTEM

Before Sonac, sensing and switching control systems which involved breaking a beam of energy were limited by vibration, dust, smoke, steam, air contamination and too much or too little light. Sonac's ultrasonic energy "beam" is completely free of these limitations. The acoustic lens on Sonac sensors can actually be painted without affecting performance. Utilizing high frequency sound also means there are no lamps to burn out. Savings in replacement parts and maintenance time often means Sonac pays for itself. Sonac is completely transistorized, providing you with a rugged, dependable electronic circuit.

These are just a few of Sonac's many uses. Optional equipment includes reflectors for precision beam and positioning control, and coupler assemblies for use with flexible tubing for remote sensor locations. This descriptive booklet will be sent to you on request.

DELAVAN
Manufacturing Company
WEST DES MOINES • IOWA

DURA PLASTIC *Teflon* PACKING *created definitely for chemicals*



DURA PLASTIC STYLE 66F SPIRAL

DURA PLASTIC STYLE 666F DIE-MOLDED RINGS

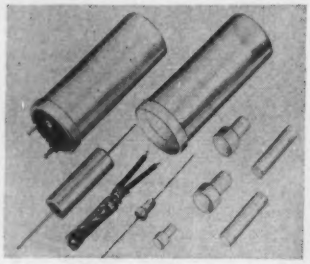
A completely lubricated TEFLON PACKING

Provides long-term, dependable sealing of corrosive fluids. For service on all liquids except molten alkali metals and some fluorine compounds in the higher temperatures. Particularly suitable for sealing rods, shafts and stems on processing equipment handling hot caustics, acids, alkalies or organic solvents from -90°F. to 450°F.

FOR FURTHER INFORMATION WRITE FOR BULLETIN NO. 461

DURAMETALLIC CORP., Kalamazoo, Michigan

Circle 541 on Page 19



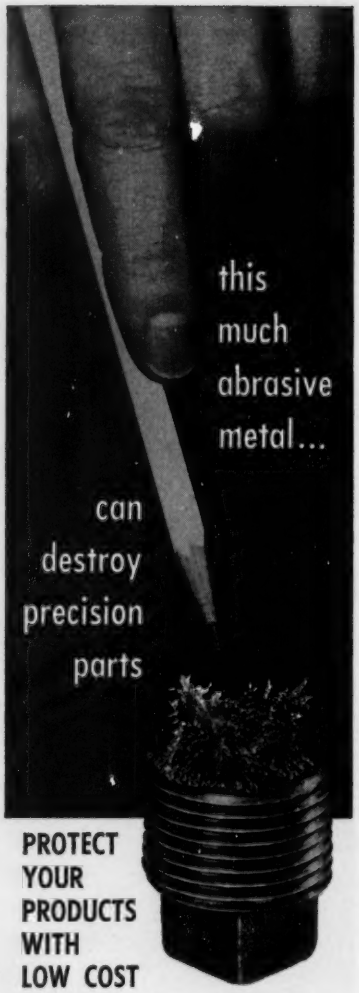
the material structure. Polyethylene actually flows with the Mylar to make a firm bond and prevent separation; there is no need for a crystalline bonding agent. Jackets permit fast, easy, economical insulation of a wide variety of electrical and electronic parts, and are available in practically any shape or size. Used on capacitors, coils, screws, and other parts where insulation against electrical effects and/or corrosion is required, they are also used to eliminate expensive handwrapping with pressure-sensitive insulation. Transparent material does not interfere with identification of product or other information. **Precision Paper Tube Co.**, Dept. MD-1, 2035 W. Charleston St., Chicago 47, Ill.

Circle 776 on Page 19

Flexible Shaft

for high-temperature uses or where corrosion is a problem

Stainless-steel, high-temperature flexible shaft is made to the requirements of the aircraft industry and held to close tolerance. The $\frac{5}{16}$-in. diam core is made up of layers of stainless-steel wire. Outer flexible interlocked casing and end fittings are also 316 and 321 stainless steel. Square fittings on the end provide the engagement and allow for slight changes in length due to varying



PROTECT YOUR PRODUCTS WITH LOW COST

LISLE *Magnetic* **PLUGS**

If your product has moving parts operating in a fluid, you can reduce costly wear with Lisle Magnetic Plugs.

Ferrous metal particles in a lubricant are a major cause of wear. The Lisle Magnetic Plug removes these particles from the lubricant — assures longer, quieter operation of the products you make.

Lisle Magnetic Plugs can be used in place of any ordinary drain or fill plug.

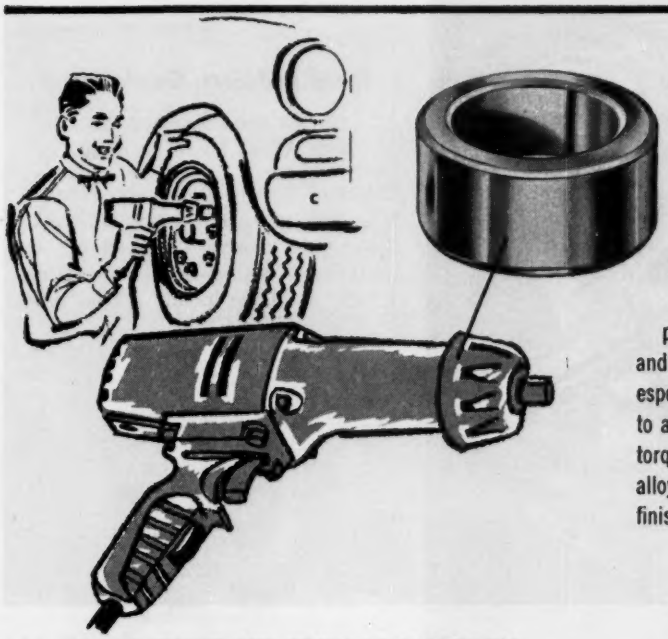
FREE Samples for Testing in Your Product!

LISLE CORPORATION
Clarinda, Iowa

Circle 542 on Page 19

600 SERIES

THE FORGEABLE BEARING ALLOYS THAT STAND UP ON THE REALLY TOUGH JOBS!

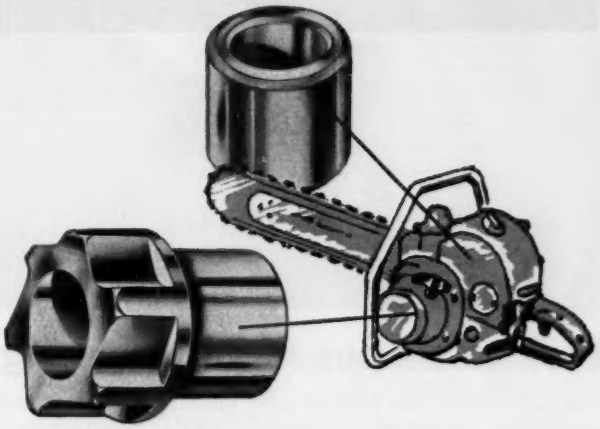


600 ALLOY NOSE BEARING WITHSTANDS THE PUNISHING SHOCK LOADS OF AN IMPACT WRENCH

This heavy-duty impact wrench takes the rigorous punishment of hard industrial use right on the nose . . . and right on the 600 Series nose bearing. This bearing was especially chosen by the manufacturer because of its ability to absorb a range of 1600 to 1800 impacts per minute at a torque of from 0 to 250 foot pounds. By specifying 600 bearing alloy, the manufacturer gets superior performance from his finished product.

600 ALLOY RATCHET AND DRIVE GEAR BEARING TAKES THE TERRIFIC POUNDING OF A HIGH POWERED CHAIN SAW

Professional woodcutters give chain saws a rough time for hours on end, all year round, and these rugged saws must be built to take punishment. With chain speeds up to 3000 feet per minute, the ratchet and drive gear bearings, for example, must have a very high strength, hardness and good resistance to wear with minimum lubrication. That's why 600 Series Alloy was specified for both parts . . . the ratchet is a forging and the bearing was produced from 600 Series rod.



MUELLER BRASS CO. SPECIALIZES IN ALLOYS FOR DIFFICULT APPLICATIONS

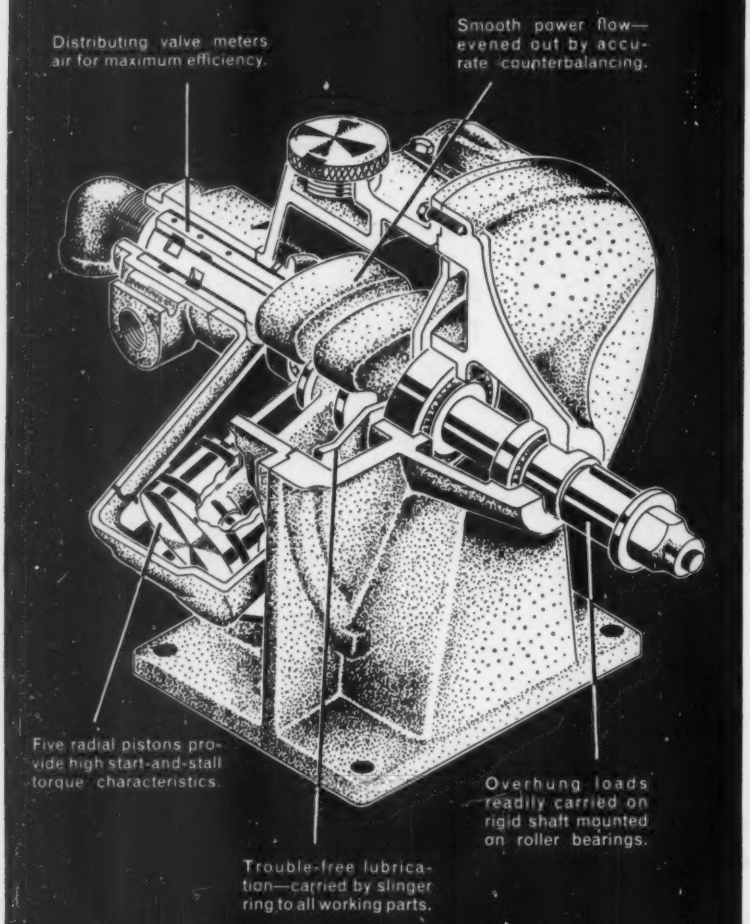
For complete engineering data, write today for Special Alloys Kit No. 13.

The alloys available from the Mueller Brass Co. range from those having high hardness and wear properties, to alloys that must possess excellent electrical conductivity, and ones that must have free-machining properties. Let our engineers help you select the alloy best suited to your exact application.

MUELLER BRASS CO. PORT HURON 20, MICHIGAN

326

GARDNER-DENVER HIGH-TORQUE
5-CYLINDER RADIAL AIR MOTOR—2 TO 16 H.P.


Distributing valve meters air for maximum efficiency.
Smooth power flow—evened out by accurate counterbalancing.
Five radial pistons provide high start-and-stall torque characteristics.
Overhung loads readily carried on rigid shaft mounted on roller bearings.
Trouble-free lubrication—carried by slinger ring to all working parts.

Look to air power for new design ideas

Gardner-Denver air motors offer positive, instantaneous control . . . continuous operation . . . reversibility . . . no spark hazard . . . can't burn out.

And remember, factory-trained specialists have parts and facilities to keep Gardner-Denver products on the go—wherever they go.

For details, consult your Gardner-Denver air power specialist, or write for Bulletin AM-1.

EQUIPMENT TODAY FOR THE CHALLENGE OF TOMORROW

GARDNER-DENVER Since 1859

GARDNER DENVER

Gardner-Denver Company, Quincy, Illinois

In Canada: Gardner-Denver Company (Canada), Ltd., 14 Curity Avenue, Toronto 16, Ontario

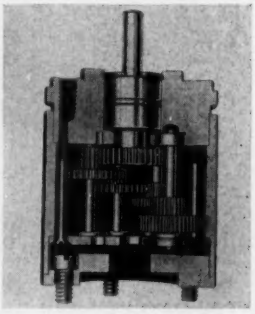
torques. Ferrules are made to attach the casing to meet application requirements. Deflection of the flexible shaft in radians per ft-lb can be held to fairly close tolerance also. Suitable for high-temperature uses or where corrosion is a problem, shaft is available in any required length. **Stow Mfg. Co.**, 11 Shear St., Binghamton, N. Y.

Circle 777 on Page 19

Speed Reducers, Gearheads

are lifetime-lubricated with ABEC-7 ball bearings

BuOrd Size-11 frame speed reducers and gearheads, made with postless-type construction, mount on standard BuOrd MK-14 servo motors. Available in any special ratio,



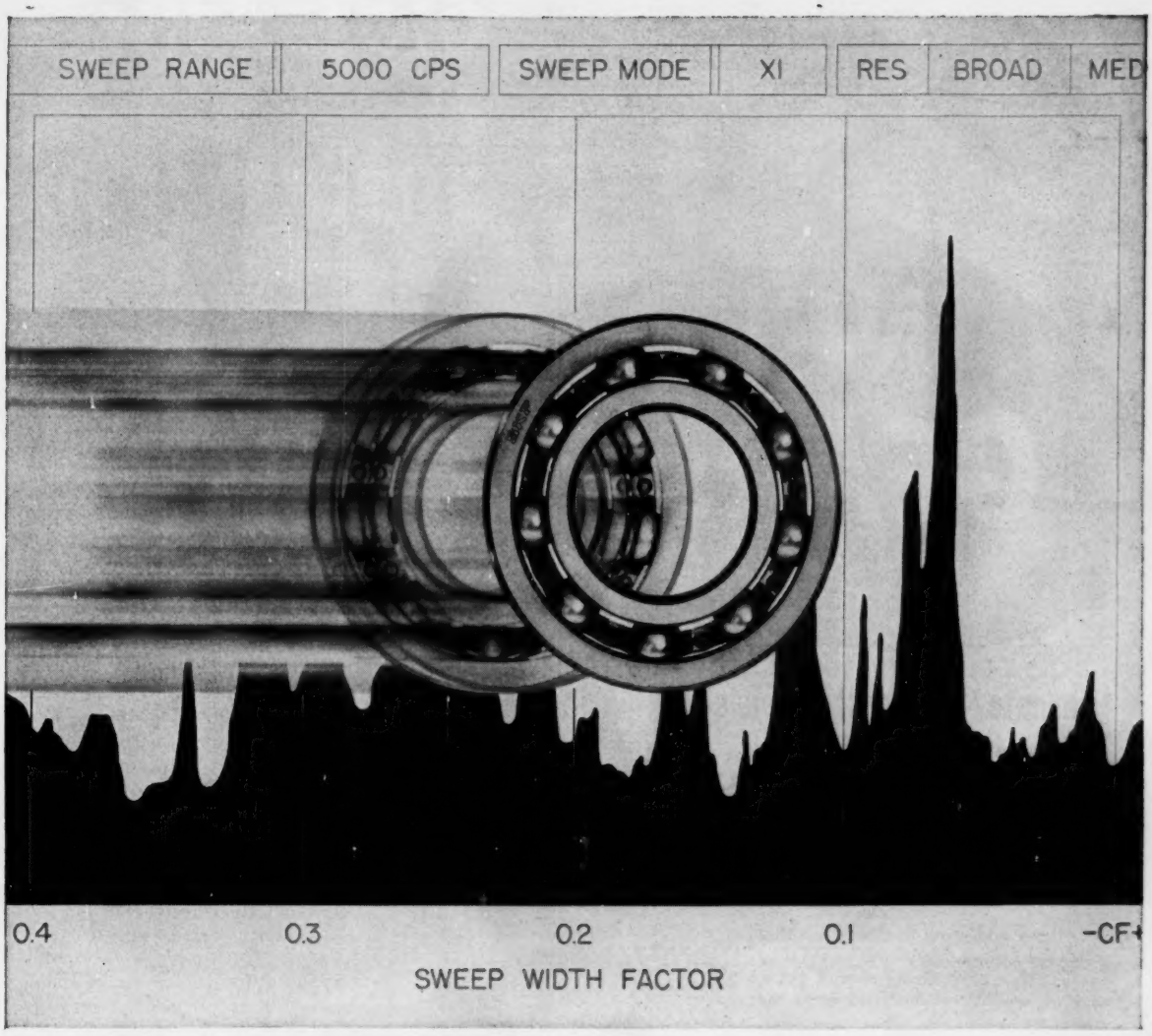
physical characteristics, and mechanical specifications, units are lifetime lubricated with ABEC-7 ball bearings throughout, and have shielded output bearings. Gears and pinions are hardened and passivated to meet corrosion-resistance requirements. Internal slip clutches are incorporated upon request. **Planet Instrument Inc.**, 616 S. Lafayette St., Fort Wayne, Ind.

Circle 778 on Page 19

Mylar-Epoxy Capacitors

are extremely thin and temperature stable

Miniature-size, Mylar-epoxy-dipped capacitors, especially suited for printed-circuit and transistor applications, feature an ultrathin shape to fit into narrow chassis spaces. Typical 0.01-mfd unit measures 0.525 in. wide and 0.225 in. thick. Excellent temperature stability results in a capacitance change of only 1.5 per cent at 85 C. Desig-



Now, SKF reduces the noise level of ball bearings by 50%!

New SKF ball bearings run twice as quietly as standard single-row deep-groove bearings – six times more quietly than bearings produced just two years ago.

They're designed especially for applications where noise is an important factor. Eight manufacturers, who use-tested them for over a year, now back-up their approvals with repeat orders.

Every bearing meets new, more critical standards. Each type and size meets special requirements for reduced vibration. Every ball meets very low waviness limits. Each cage meets critical standards for smooth, quiet performance.

SKF will make a comparison check of these improved bearings against the bearings you're now using. See for yourself! Just call the SKF branch office nearest you. 6013

Spherical, Cylindrical, Ball, "Thrust" Tapered and REED Miniature Bearings

EVERY TYPE—EVERY USE

SKF®

SKF INDUSTRIES, INC., PHILADELPHIA 32, PA.

*REG. U.S. PAT. OFF.

Eliminate "high-cost specials" by standardizing on

AMERICAN STOCK GEARS

Investigate and you'll probably find that instead of having to go to the added time and expense of ordering special gears, that your needs can be filled from the American line.

American is a 'complete' stock gear line. Manufactured by Perfection — a veteran of over 30 years in the gear business — these gears are made to the most precise standards, from the highest quality materials. This popular line includes brass, bronze, steel, semi-steel, cast iron, and non-metallic gears in a range of 48 to 3 diametral pitch.

You'll save time and money . . . save on inventory . . . simplify purchasing and have less lost production time by procuring your stock gear needs from your nearby distributor of American Stock Gears.

Ask for FREE copy of American Stock Gear Catalog No. 360 containing detailed information and engineering data.

AMERICAN STOCK GEAR division
Perfection Gear Co., Harvey, Illinois

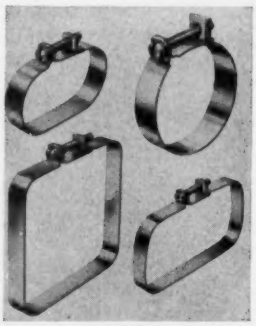
nated Type MCA, units operate from −55 to +100 C without derating. Epoxy coating provides high resistance to moisture and chemicals, and protects against solder damage. Units can be closely stacked without danger of arcing or shorting, and do not melt or drip under excessive heat. Capacitors are available in a wide range of values from 0.01 to 0.33 mfd. Plug-in leads are either straight or formed. **Hopkins Engineering Co.**, 12900 Foothill Blvd., San Fernando, Calif.

Circle 779 on Page 19

Band Clamps

are available in various shapes and sizes

Designed to meet fast-assembly hose-connection requirements of automotive, farm, construction equipment, machine tool, appliance, and other original-equipment manufacturers, Auto Clamps are now available in various band shapes and sizes. Standard Clamps are cold-rolled strip steel, plated for corrosion resistance. They are a solid, flat, ½-in. wide band of proper gage to provide strength, flexibility, and a leakproof seal. Standard units have plated fillister-head screw and nut for easy tightening with a screw-



Circle 546 on Page 19

Circle 547 on Page 19→

NICKELOID IS EVERYWHERE

IN THE GAME ROOM

IN MOST ANY ROOM

IN THE KITCHEN

These eye-catching products use functionally a basic Nickeloid Metal. The finish of Chromium, Nickel, Brass or Copper is electroplated to a base metal, usually Steel (but often Zinc, Brass or Copper).

Mostly, Nickeloid Metals are supplied in continuous coils in widths up to 24" for modern, low cost fabrication. They're also available in sheets and strips. Optional: bright or satin finishes, plating one or both sides, a galaxy of stunning patterns and crimps.

Quality plating produces metals so durable they can be fabricated, even quite severely drawn or bent. Rejects minimized. For severe stamping, we offer Mar-Not protective coating that is easily peeled off after its job is done.

These handsome articles of daily use are striking indeed! Not a little of this is achieved by the functional use of bright plated Nickeloid Metals in Chrome, Brass or Copper finishes. But look again! These pictures carry a deeper, even more dramatic story . . . the story of a *new concept* of manufacture. Not always do artisans work with raw steel sheet. Not always is the final finish applied by the extra step of painting or plating. With Nickeloid Metals this finish is built-in, and it's done by a company which has dedicated itself to electroplating of sheets and coils for industry for over 60 years! The use of Nickeloid Metals as a pre-finished raw material proves the theorem that a straight line is the shortest distance between two points. Write for free Introductory Kit that unfolds the entire story and provides you with metal samples. Or, phone a Nickeloid sales office in one of the principal cities.

AMERICAN NICKELOID COMPANY · PERU 8, ILLINOIS

America's Pioneer Manufacturer of Pre-Finished Metals—Since 1898

Is This Job for You?

BACKGROUND—Recent degree in mechanical or electrical engineering. About three years of design-engineering experience.

ABILITIES—Able to evaluate technical information on design techniques, new machines, components. Provable ability to write clearly and accurately. Should work well with people, have initiative and imagination, demonstrate creative as well as practical ability.

ENVIRONMENT—Cleveland, Ohio, with some out-of-town travel. As assistant editor on MD's staff of 21 engineer-editors. In Penton Publishing Company, a growth company, with 5 magazines and some 60 editors.

COMPENSATIONS—Salary comparable to that in industry. Chance to grow within the company. Unusual opportunity to broaden education, experience, and contacts. Stimulating work.

* * *

If this appeals to you not merely as a job but as the basis of a career, write at once (with all pertinent facts) to the Editor, MACHINE DESIGN, Penton Building, Cleveland 13, Ohio.

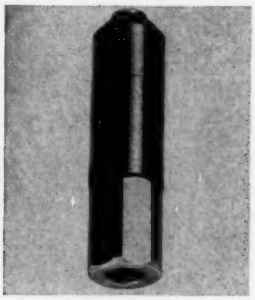
driver. They are also available with stainless-steel band and other screw-head styles and materials. **Wittek Mfg. Co.**, 4305 W. 24th Place, Chicago 23, Ill.

Circle 780 on Page 19

Poppet Valve

releases static air pressure quickly

Recycling bleeder-type poppet valve is used primarily to actuate four-way bleeder-type air-control valves. Pressure of plunger causes automatic diminution of static air pressure from pilot chambers of bleeder-type valves, and opens poppet at bottom of valve. Poppet is unseated until all



air is released, then reseats even though plunger is still depressed. Valve can be operated manually or by mechanical means. Unit is 2⅜ in. long, has ⅛-in. NPT inlet and diameter of ¾ in. **Novi-Matic Valve Div., Novi Tool & Machine Co.**, 25806 Novi Rd., Novi, Mich.

Circle 781 on Page 19

Subminiature Readout

displays colored words and backgrounds

Series 120ooo subminiature readout, compact and lightweight, is suited for applications where space and weight are at a premium. It is designed for use with computers, airborne equipment, instruments, control systems, production and inventory controls, and other electronic or electrical test equipment. Unit now displays colored words and backgrounds. Readout operates on a rear-projection principle. Master condensing lens contains twelve individual positions or lenses, on each

(*Please turn to Page 240*)

MEEHANITE® MEANS BETTER CASTINGS

By W. H. MOORE
Vice President
Meehanite Metal Corp.

What you should know about Meehanite Metal

WHY THERE IS NO EQUIVALENT

How many times have you been told "I can give you something just as good as Meehanite® and at a lower price" only to find that the castings did not meet your standard of quality.

Actually there is no equivalent for Meehanite metal. Here's why: The exclusive Meehanite process makes use of 32 patented procedures that are essential to the production of highest quality castings and which can be used only by bonafide Meehanite licensees. These procedures relate to all phases of manufacture including processing agents, melting furnaces, sand control, and molding to insure the integrity exhibited by every Meehanite casting. More than 200 Meehanite foundries throughout the world prove the validity of these techniques and share in 35 years of technological know-how that truly puts Meehanite metal in a class by itself.

The production of Meehanite® involves a lengthy training period under the direction of Meehanite engineers, and a continuing program of metallurgical help and advice. Set standards of operation enable Meehanite foundry-men to apply structural control to castings on a day by day basis.

Essentially, the metallurgical control in the production of Meehanite castings involves obtaining a balance between undercooling produced in the melting operation and nucleation produced by processing the molten metal with alkaline earth agents. The initial degree of undercooling is related to the mass of the casting to be poured and the density and physical properties required. This is then modified by nucleation to force deposition of graphite at exactly the right time during solidification so as to give the right size and shape and distribution to the free graphite at the same time maintaining the character of the metallic matrix. The net result is predictable properties and uniform structure in every section of a casting and from casting to casting.

Gray cast iron made to a chemical specification without benefit of controlled undercooling is influenced by mass effect to a maximum degree and for this and other reasons cannot be considered an equivalent to Meehanite.

There are more than 26 different types of Meehanite metal available, each of which is specifically designed for a given set of service conditions.

Accept no substitute for Meehanite quality and performance. Specify Meehanite castings and be sure. For more information about Meehanite castings and the foundries making them, write to: *Meehanite Metal Corporation, 714 North Avenue, New Rochelle, New York.*

MEEHANITE METAL

Meehanite Castings Are Made Only By Meehanite Foundries

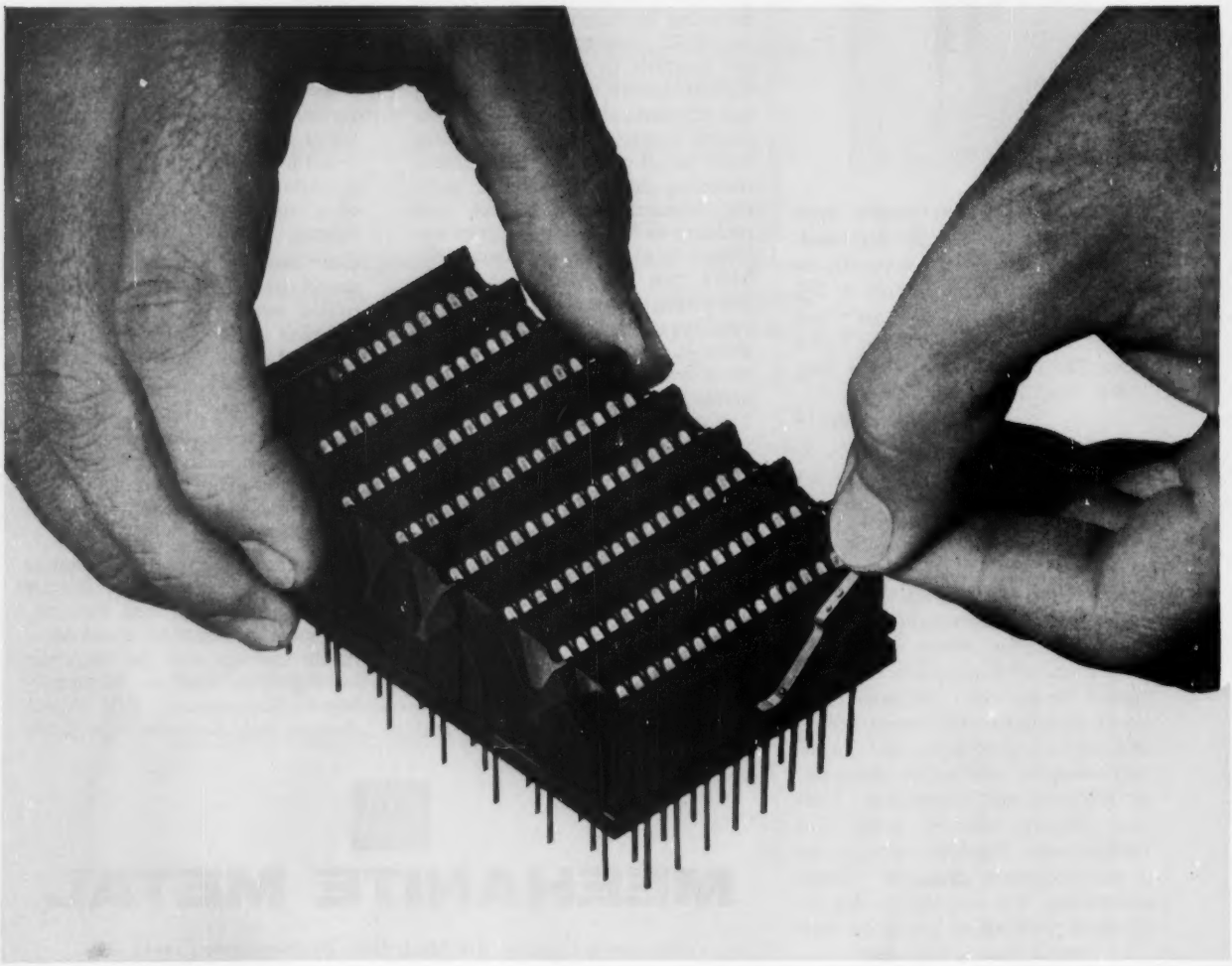
Circle 549 on Page 19

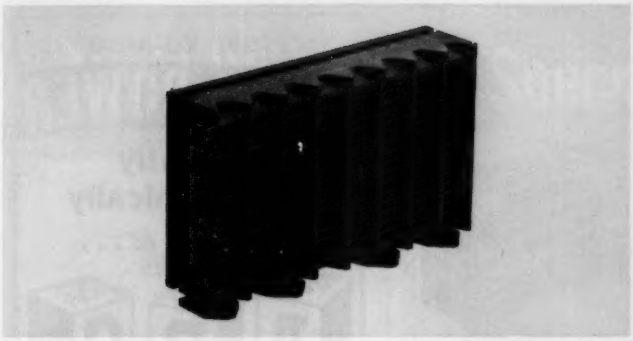
SYLVANIA PRODUCES & DELIVERS THE COMPLETED ASSEMBLY

—at substantial savings to IBM

This electrical connector block is a vital link in the electrical system of an IBM computer. Unless it is built to exact tolerances, the computer can malfunction.

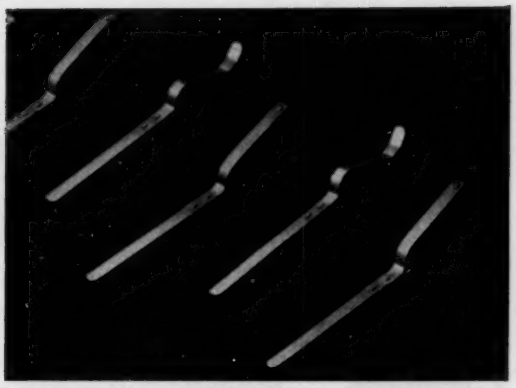
To make this critical part, IBM chose Sylvania because we could perform the entire production sequence—from raw materials to completed assemblies built to tolerances in terms of thousandths of an inch. It soon proved the Sylvania experience paid off in two ways: in production economies and in fast delivery too. Total result: a better connector block—at lower cost. (For details see captions to pictures on these pages.) For full information on how Sylvania custom facilities can benefit *you*, or for a quote on a specific project, write Sylvania Electric Products Inc., Parts Division, Warren, Penn.





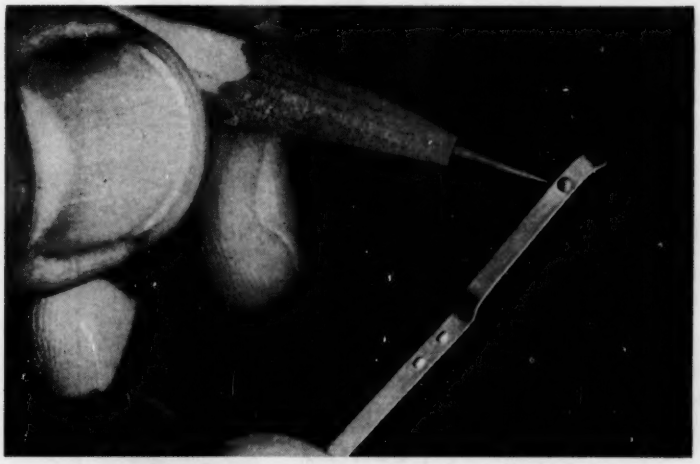
MOLDED FROM PLASTIC by Sylvania, the IBM connector block meets tightest specifications. This is possible because Sylvania maintains one of the world's most modern and complete lines of automatic molding equipment. This equipment permits Sylvania to handle volume orders for compression, injection and transfer molding. And a unique bank of rotary presses can produce millions of precision parts each day—even using phenolics and urea.

Result to IBM? Precisely formed parts to fill high-volume requirements.

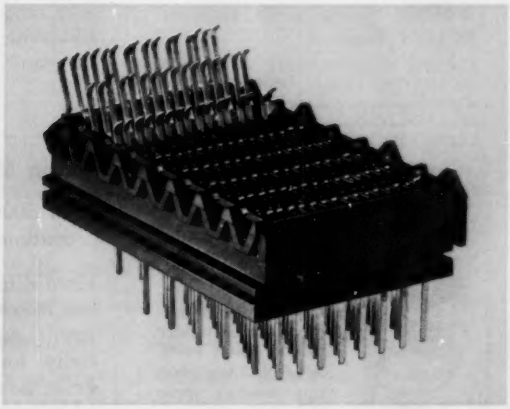


MADE FROM SYLVANIA WIRE, precision-rolled ribbon connectors offer high reliability when the circuitry is completed using wire wrap contact methods. The cross section of the ribbon—.023″ x .062″—and the corner radius of .003″ were accomplished on a special three-head tandem rolling mill and special forming equipment.

Result of this flexibility to IBM? Top reliability at close tolerances.



CUSTOM METAL STAMPING AND DOT WELDING, in one operation, also paid big dividends to IBM. The original plans called for forming parts and then gold-plating the entire contact. Following a request by IBM to extend contact life and reduce costs, Sylvania experience paid off. Sylvania Engineers demonstrated they could weld a tiny gold dot at the contact point economically while maintaining close tolerance on the critical dimensions of the formed contact. High-speed, high-volume techniques enable Sylvania to meet critical deflection and sheer tests. Sylvania maintains a metal stamping facility which includes multi-slide machines, vertical presses, and specially developed machines to help solve your special problems.



CUSTOM ASSEMBLY by Sylvania of the block and the parade of contacts is handled by our corps of trained specialists. Many of our customers have found that Sylvania can often deliver completely assembled and packaged products—using either all Sylvania components or all customer components, or both—*at lower cost than is possible in the customer's own facilities.*

Result to IBM? Many, many thousands of completed top-quality assemblies per month, and to tolerances specified for automatic wire wrap.

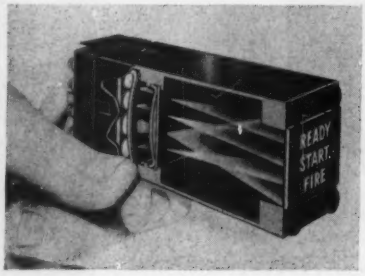
QC SERVICE MEANS QUALITY CONTROL!

At Sylvania, a tough-minded, hard-to-please quality control department has full authority for assuring the parts Sylvania produces meet your most stringent specifications. Example of this thoroughness: for the IBM connector block, Sylvania used *100% inspection!*

SYLVANIA

Subsidiary of **GENERAL TELEPHONE & ELECTRONICS**

(Continued from Page 237)



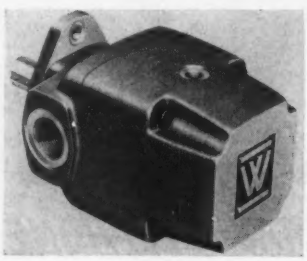
of which is printed the desired word, message, or color. When one of the twelve lamps at the rear of the unit is lighted, lamp projects the corresponding work or color onto the viewing screen at the front of the unit. Readout features modular construction and an aluminum case. It is 1 in. wide, $1\frac{5}{16}$ in. high, $3\frac{5}{16}$ in. long, and weighs $3\frac{1}{2}$ oz. **Industrial Electronic Engineers Inc.**, 5528 Vineland Ave., North Hollywood, Calif.

Circle 782 on Page 19

Piston Motors and Pumps

for 3000 psi continuous duty

Fixed-displacement, axial-type piston motors and pumps of four different capacities, developed especially for the industrial machine field, have displacements of 0.72, 1.09, 1.45, and 1.81 cu in. per revolution. Series C3F units rated for continuous duty of 3000 psi and intermittent pressures to 3500 psi, produce capacities from 3.3 to 8.5 gpm at 1200 rpm, and 5 to 14 gpm at 1800 rpm. Operating speeds are up to 2400 rpm, and the largest unit can deliver 18 gpm at this speed. Used as motors, four sizes have theoretical torque ranges of 11.52, 17.28, 23.04, and 28.80 lb-in. per 100 psi, or output horsepowers from 5.5 to 14 at 1200 rpm and 8 to 22 at 1800 rpm, operating at 3000 psi.



RULON® AND TEFLON

Replace costly machined or molded parts with formed RULON Tape.

Leading manufacturers across the country are cutting design costs by stamping or post-forming parts from RULON (filled TFE) tape. With Dixon's RULON Tape in thicknesses from .004" to .125", you pay only for what you *use*. You use a *minimum* of material . . . and reduce costs up to 10 to 1. You take advantage of RULON'S plastic memory, too, for tighter fits and better seals.

RULON Tape gives your product these performance-improving qualities: (1) low friction, (2) high wear resistance, (3) low deformation under load, (4) wide temp. tolerance (−400°F to +500°F), (5) chemical inertness, (6) lube-free operation, and (7) zero water absorption.

Whether you need stamped or post-formed parts for pumps, valves, compressors, bearings, meters, or what have you, it pays to rely on (1) Dixon's wide selection of basic shapes (in both RULON and Teflon), (2) Dixon's knowledge of fluorocarbon reinforcing agents, and (3) Dixon's facilities for fabricating parts to print.

See RULON designers guide book — Bulletin #9572 in Sweet's Product Design File, or send details for recommendations. DIXON CORPORATION, 100 BURNSIDE ST., BRISTOL, RHODE ISLAND. * DuPont T.M.

DIXON

Circle 551 on Page 19

How to use
FLUID POWER
✓ efficiently
✓ economically
is as easy as . . .

when you specify

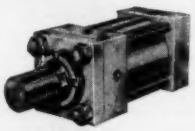
PROVEN QUALITY
SP
CYLINDERS · BOOSTERS

SERIES A

Standard Cylinders AIR or OIL Without Modification

Save money with S-P's complete line; rated 200 psi air, 500 psi oil or water; 23 mounting types; 11 bore sizes—1½" thru 14"; see Catalog 110C.

SERIES B



HIGH PRESSURE Hydraulic Cylinders

Get smoother, more precise power; ruggedly built, interchangeable; 2000 psi (3000 psi non-shock); 12 bore sizes—1⅛" thru 12"; get Catalog 117.

SERIES C

Air-Oil BOOSTERS

Save money, save space; boost 80 psi line air to 3000 psi hydraulic power with no added power consumption, no maintenance; see Catalog 116.

FREE Engineering Service Phone or Write Today

Find us fast in the 'Yellow Pages'

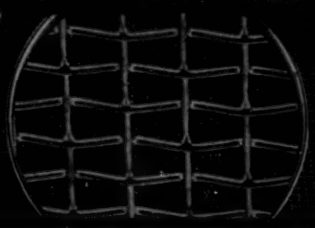
A-2883A

The S-P Manufacturing Corp.
A BASSETT COMPANY
30201 Aurora Road • Cleveland 39, Ohio

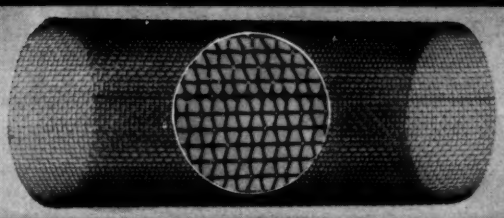
Circle 552 on Page 19

Need Wire Cloth Specials? Call *Cambridge*

BRAZED

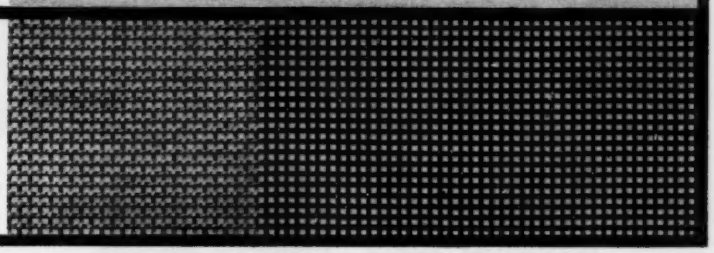


SEAMLESS



TEFLON* COATED

Right Side Coated



*Reg. T. M. of DuPont Company

These are just 3 of the many wire cloth specialties Cambridge can produce for you—no matter how large or small a quantity you need. Or, if you have an extra-special problem, there's an expert on hand to discuss your special needs . . . your Cambridge Field Engineer. He can show you how to get the results you want—in the quickest possible time at the lowest possible cost.

Your Cambridge Field Engineer is listed in the Yellow Pages under "Wire Cloth." Call on him at any time. Or, write for illustrated, 120-page catalog.

If Your Problem Involves Standard Metals or Alloys...

we make wire cloth from any metal or alloy that can be drawn into wire . . . in nine basic weaves, and with accurate mesh count and mesh size. Ask about immediate deliveries from our enormous stocks of the most frequently used types of cloth in a wide range of mesh sizes.

Refer to our technical data sheets in CHEMICAL ENGINEERING CATALOG, Pages 185

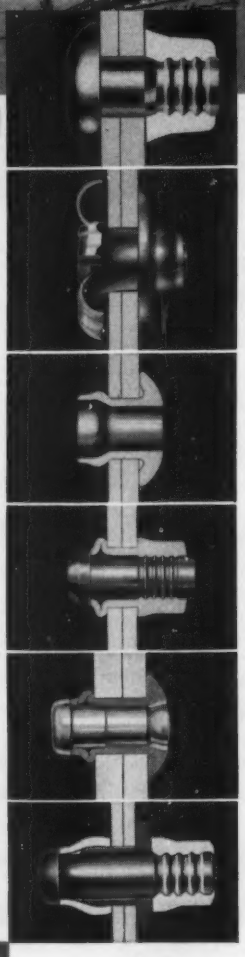
THE CAMBRIDGE WIRE CLOTH CO.

DEPARTMENT N • CAMBRIDGE 2, MARYLAND

Manufacturers of Metal-Mesh Conveyor Belts, Flat Wire Conveyor Belts, Wire Cloth, Wire Cloth Fabrications and Gripper® Metal-Mesh Slings.

- FASTER, EASIER INSTALLATION
- GREATER STRENGTH
- UNIFORM TENSION
- MAXIMUM SHEAR STRENGTH
- PRECISION FIT
- LOWER INSTALLED COST

Huck permanent fasteners are available in many types, shapes and sizes, from 1/8" to 3/4" diameter, to meet the requirements of all types of manufacturing, from railroad cars, trailers, buses, ships, blowers, appliances, to farm equipment and prefab buildings. These and many other users specify Huck fasteners for reasons of economy, speed of application, strength and dependability. You too, may find the answer to faster, better, cost-cutting assembly by investigating Huck's advantages. Write for literature, or ask for a Huck Sales Engineer who will be glad to explain the advantages of Huck Fasteners in your product. No obligation.



CL— Commercial Huckbolt

DR— Daisy Blind Rivet

PT— Pull-Thru Blind Rivet

OS— Oversize Structural Blind Rivet

MLS — Mechanical Lock Spindle Blind Rivet

BL— Blind Huckbolt

HUCK MANUFACTURING COMPANY

2480 Bellevue Avenue • Detroit 7, Michigan • Phone WA 3-4500

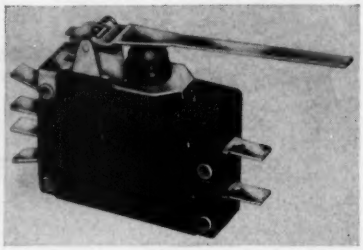
Largest size, operating at 2400 rpm, delivers 28 hp at 3000 psi. **Webster Electric Co.**, Racine, Wis.

Circle 783 on Page 19

Sealed Switches

provide double-circuit control

Double-pole double-throw switching, or operation of two independent single-pole double-throw switches by the same actuating button is available in DA60 series of low-cost, high-performance, snap-acting switches. Case halves are permanently sealed together, and a flexible silicone boot seals the clearance



between case and operating button. Switches are furnished with plain button, hinged lever actuator, or hinged roller-lever actuator. Switches are rated at 15 amp, 125/250 v ac; 3/4 hp, 125 v ac; or 1 1/2 hp, 250 v ac. **Unimax Switch Div., W. L. Maxson Corp.**, Ives Road, Wallingford, Conn.

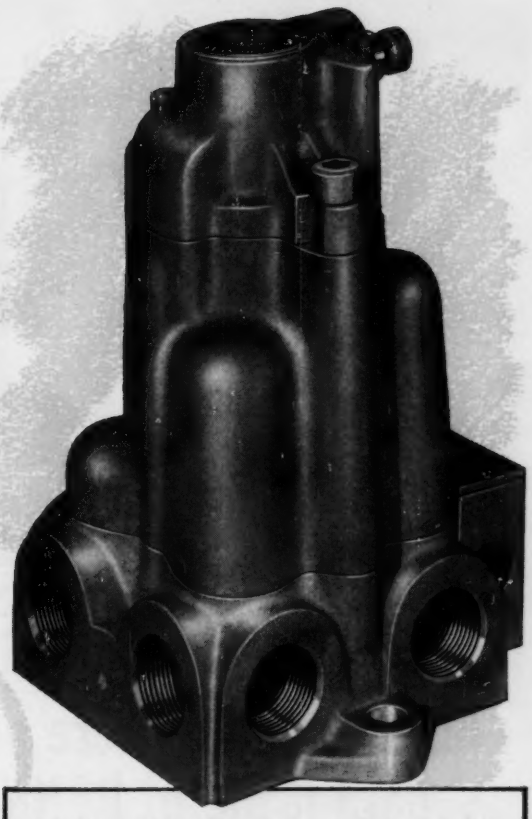
Circle 784 on Page 19

Polyurethane Sealant

has excellent resistance to water and alkali

No. 829-901 Black U. I. polyurethane sealant, available for a wide variety of industrial uses, is a soft, high-modulus composition which is easily applied with either calking gun or knife. It is furnished in a single package, requires no field mixing or curing accelerators, and does not shrink on aging. It has excellent adhesive properties that withstand significant changes in temperature within −75 to +150 C temperatures. Sealant is flexible on aging, has good resistance to chemicals, and serves as a barrier protection between dissimilar metals. Film-forming urethanes in the sealant provide a tough skin in one to three days, and the material is com-

It's new! HUNT ONE INCH PDQ VALVE



Cylinder ports front, side and bottom-tapped; supply and exhaust ports side and bottom-tapped; basic 1 in. PDQ available tapped ¾, 1 or 1¼ in. NPT (also basic ½ in. PDQ tapped ⅜, ½ or ¾ in. NPT); for air or vacuum service, pressures from 0 to 125 psig; meets JIC Standards.

TOPS in accessibility
TOPS in simplicity
TOPS in speed
TOPS in capacity
TOPS in quality

Now you can have all the performance-proved advantages of Hunt's PDQ center-line design PLUS the high capacity of full 1" size. The PDQ's short stroke pilot and compact, lightweight, single spindle poppet provide lightning-fast response and near-instantaneous full flow. All this in a compact package weighing only 10.8 pounds!

Look at these performance figures. The 1" PDQ, with 100 psig supply, fills a 400 cu. in. vessel to 90 psig in but 0.288 seconds (17.3 electrical cycles) . . . exhausts the same vessel from 100 to 10 psig in 0.200 seconds (12 electrical cycles) and, at 100 psig, its flow capacity is 850 cfm free air!

Downtime? Short stroke, shock-reducing all-aluminum construction and built-in wear compensation assure millions of cycles of trouble-free operation. Then, to repack, simply loosen 2 cap screws . . . twist pilot cap . . . remove pilot and valve housing. Piping is undisturbed . . . electrical connections are plug-in, wiring need not be touched.

If you're looking for better, lower cost, more dependable performance on new or existing equipment . . . before you buy any valve, be sure you see the PDQ. Call your nearby Hunt Representative today. He's listed in Sweet's Product Design File.

For more information, write for Bulletin 602. Address Dept. MD-261, Hunt Valve Company, Salem, Ohio.

HUNT

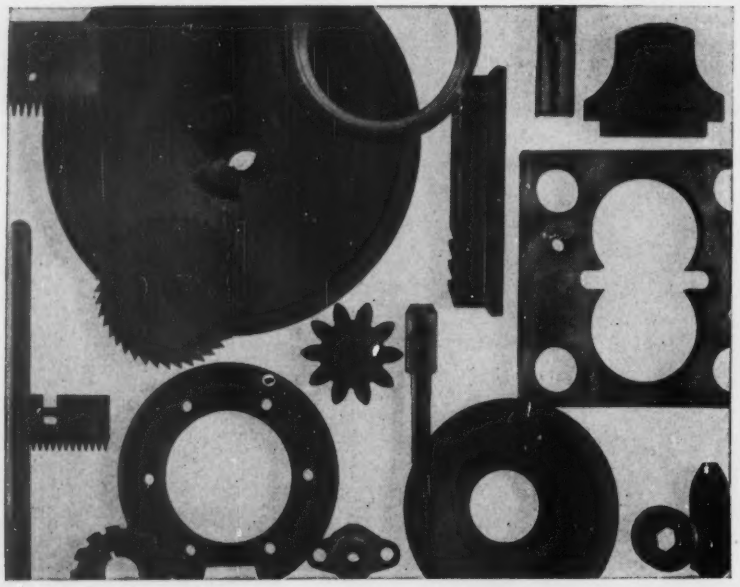
QUICK-AS-WINK® AIR AND HYDRAULIC

VALVES

HUNT VALVE COMPANY • DIVISION OF IBEC • SALEM, OHIO

3010

Circle 555 on Page 19



Made of Kennametal* and Kentanium,* these parts perform better, longer. Punches, dies, seal rings, nozzles, pump parts, temperature sensing elements and hundreds of other critical parts are custom-engineered to solve specific design and materials problems.

All these parts were problems ...until made of KENNAMETAL

Some of the machine components shown above must function at points of extreme abrasion. Others are subjected to the attack of corrosive fluids... or must retain strength at high temperatures. For longest life under these conditions, they have been made of Kennametal or Kentanium. These two hard carbide alloys can be made in about any shape to solve design problems. When new ideas create new design or materials problems, Kennametal or Kentanium often provide the answer. Chances are one or a combination of the unique properties of these materials can help you carry out some design idea.

OUTSTANDING PROPERTIES

- An extremely high rigidity—up to 94 million YME (compared with steel's 30 million).
- Density of compositions ranges from 5.7 to over 15.0 gms/cc compared to steel at 7.8.
- Compositions available to resist corrosion-wear conditions encountered with nitric, sulfuric and hydrochloric acids, and sodium hydroxide.
- Kennametal is extremely hard (up to 94 Rockwell A) and outwears steel as much as 100 times.
- Kentanium retains sufficient strength for continuous operation at temperatures of 2200°F and up to 5000°F for shorter periods.

If you'd like more information, contact a Kennametal Representative or write us direct for Booklets "Properties of Kennametal" and "Proven Uses of Kennametal and Kentanium." KENNAMETAL INC., Department MD, Latrobe, Pennsylvania.

*Kennametal is the registered trademark of a series of hard carbide alloys of tungsten, tungsten-titanium and tantalum. Kentanium is the registered trademark of a series for applications requiring a lighter weight material, or maximum resistance to temperature extremes. 33551

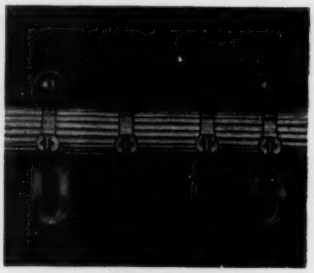
INDUSTRY AND KENNAMETAL ...Partners in Progress

pletely cured to a durable, elastic rubber in 10 to 14 days. Material has excellent resistance to water and alkali, and is inert to most chemicals, solvents, and corrosive atmospheres. **Fabrics and Finishes Dept., E. I. duPont de Nemours & Co.**, Wilmington 98, Del.

Circle 785 on Page 19

Harness Clamp

takes harness sizes to 4 in.



Premountable Ty-Rap harness clamp, once installed, does not have to be unmounted should harness need reworking. Two mounted-bolt holes provide firmer clamping. Clamp takes a range of harness sizes to 4 in. Used in conjunction with Ty-Rap cable ties and straps, this clamp and a Ty-Rap replace 52 sizes of conventional clamps. **Thomas & Betts Co.**, 36 Butler St., Elizabeth, N. J.

Circle 786 on Page 19

Magnetic Clutch

has output torque of 40 oz-in.

T502 single-end magnetic clutch is a basic, direct-acting unit. It is designed so that when the coil is de-energized, input and output shafts are free to rotate independently of each other. Upon energization of the magnetic coil, couplings become engaged and torque is transmitted through the unit. Clutch meets requirements of MIL-E-5272A. Typical characteristics, while operating at 24 to 28 v dc, include: Output torque of 40 oz-in.; backlash (engaged) of 5 min of arc; power consumption of 3 w; weight, 13 oz, and maximum speed, 5000 rpm. **Component Div., Sterling Precision Corp.**, 5 Sintsink Drive, Port Washington, L. I., N. Y.

Circle 787 on Page 19

WEBSTER'S NEW C3F PISTON MOTOR AND PUMP

compact, simple design ■ exceptionally serviceable!

This new hydraulic power unit — developed especially for the machine tool field — features unique application and servicing advantages. Examples: (1) small "package" to fit in close quarters — SAE "A" size mounting can be used with easy access to both mounting holes; (2) simplest axial-type piston pump on the market — fewest parts, fewer potential trouble spots, greater economy; (3) easily serviced — all critical moving parts can be readily replaced in the field. Shaft can be exchanged by disassembling seal end only; (4) unit can be disassembled and the rotation reversed in the field — can be arranged for use as a dual rotation motor; (5) variety of mounting styles — mounting plate and seal assembly is a separate piece and can be furnished in several mounting styles; (6) drive shafts are available with keyways or splines.

The C3F Series can be used as a hydraulic motor (remote rotary locations, screw feeds — anywhere an electric motor might be used) or as a hydraulic pump . . . wherever high torque and smooth, steady force are required. It is available in four sizes — from .72 to 1.81 cubic inches per revolution. Capacities range from 3.3 to 8.5 gpm at 1200 rpm; 7 to 18 gpm at 2400 rpm.

C3F SERIES

FIXED DISPLACEMENT AXIAL-TYPE PISTON MOTORS AND PUMPS

Drive: direct, gear or belt

Displacements: four sizes; .72, 1.09, 1.45, 1.81 cu. in. per rev.

Porting: Side ports — horizontal or vertical — handle 1" NPT inlet or 1¼" "O" ring straight thread

Capacity: 3.3 to 8.5 gpm at 1200 rpm
7 to 18 gpm at 2400 rpm

Speeds: to 3000 rpm

Pressures: continuous duty 3000 psi, intermittent rating to 3500

When used as motor:

Torque range (theoretical): four sizes; 11.52, 17.28, 23.04, 28.80 inch pounds per 100 psi

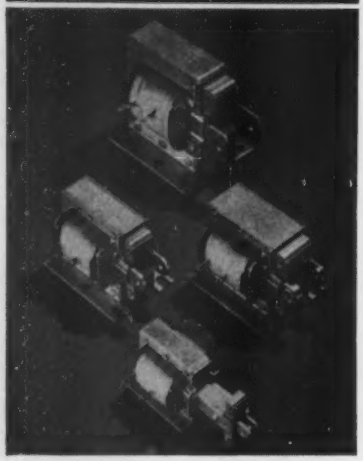
Output: 5.5 to 14 hp. at 3000 psi at 1200 rpm
11 to 28 hp. at 3000 psi at 2400 rpm

OIL HYDRAULICS DIVISION
WEBSTER ELECTRIC
RACINE · WIS

Franklin adv. W127

Circle 557 on Page 19

NOW! DORMEYER PRESENTS "AMERICA'S FINEST SOLENOID LINE"



here it is—completely new—completely redesigned—the

DORMEYER SUPER-T-LINE

Check these new and improved features

- Heavier, Sturdier Mounting Brackets
- Extra Heavy, Well Supported Plunger
- High Seating Pull without excessive AC Hum
- High Dielectric Bakelite Bobbin
- Stainless Steel, Non-Rusting, Anti-Residual Spring
- Larger Contact Area between Co-acting Members for Longer Life
- Stronger, Heavy Gauge, Pull-Bar
- Moisture Resistant Coil
- Moisture Proofed or Epoxy Resin Encapsulated Coils available for High Humidity Conditions
- Design provides for Maximum Work without Power Drop-Off

•

More rugged, with greater designed-in and built-in dependability, the new Super-T deserves to be called "America's Finest Solenoid Line". Write for Catalog today!

DORMEYER INDUSTRIES
FACTORIES IN CHICAGO AND KENTLAND, INDIANA

Also Builders of Special Coils and Transformers

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Circle 558 on Page 19

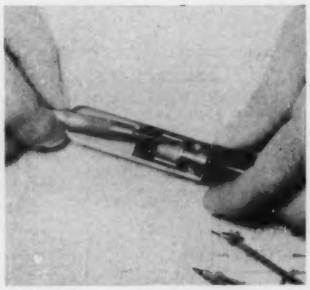
ENGINEERING DEPARTMENT

EQUIPMENT

Pencil Pointer

is clean to use and transport

Twirl-A-Point contains an abrasive ring formed from tungsten-carbide grits brazed to steel. It also incorporates a serrated vinyl wiping surface of a shape which effectively cleans the sharpened pencil point. Stop plug serves both to position pencil longitudinally in device and as a check valve to restrict the



passage of graphite residue from capped receptacle back into operating chamber. Pointer is portable, and is clean to use and transport. Aluminum case is 0.7 in. in diam, and over-all length of the unit is 3.5 in. Photograph shows the device in cross-section, pencil lead in contact with abrasive surface. Jones & Co., P. O. Box 2074, South Bend, Ind.

Circle 788 on Page 19

Drafting Tables

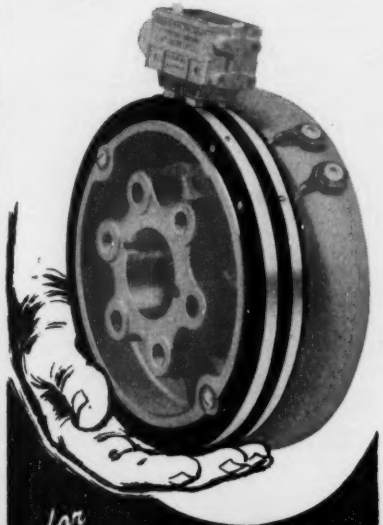
have adjustable springs on tilting quadrant

Complete counterbalancing of drafting top on improved May-O-Matic and Desk-O-Matic tables gives operator weightfree control of angle position, whether the action be towards the horizontal or the vertical. Springs on the tilting quadrant are adjustable, permitting the operator to compensate for edge weight induced by the addition of drafting accessories. After adjustment for the added weight, top goes

example...

FIBERITE

at work in electric clutches



for Warner Electric Brake and Clutch Co., Beloit, Wis.

Warner Electric needed a plastic molded part to transmit power from brushes to a clutch magnet and turned the job over to Toledo Commutator Co., Owosso, Mich., and Great Lakes Plastics, Inc., Salem, Mich. These were some of the specifications—

- compatibility with bronze inserts from −20 to +200° F
- stability under rotational speeds to 3600 rpm
- dielectric resistance up to 2000 volts
- machinability
- high strength and durability
- minimum weight
- pleasing appearance
- competitive price

FIBERITE No. 4032 olive green (2 stage glass phenolic compound) did the job superlatively. On a production basis!

Plastic materials for special applications—from missiles to dielectric inserts—are our stock in trade.

Let FIBERITE engineers work for you. Our free catalog tells the story... send for it today!

THE FIBERITE CORPORATION
Dept. MD-2
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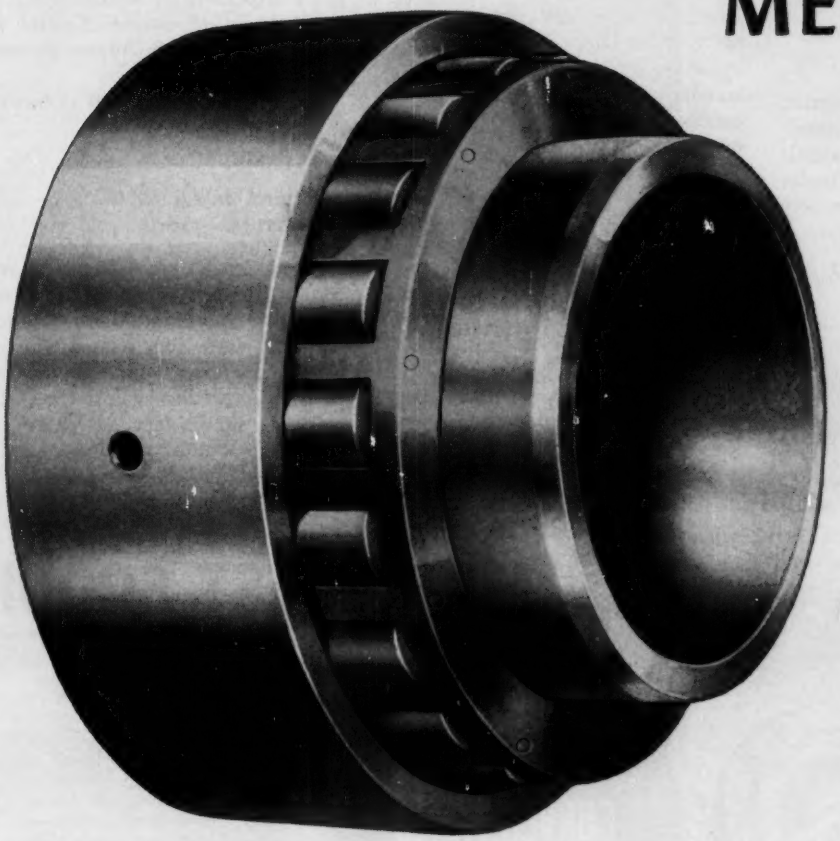
Winona, Minnesota

Circle 559 on Page 19

Rugged IS THE WORD... *for* RADIAL ROLLER BEARINGS *by* MESSINGER



TYPICAL APPLICATIONS

Straightener Rolls; Back-up Rolls; Press Rolls; Work Rolls; Drive Shafts of all kinds; Beaters; Embossers; Rudder Shafts; Heavy-duty Cranes.

The list at right is merely indicative of the wide range of applications for these *quality* bearings... developed by Messinger to assure long service with enduring accuracy. Made from Messinger special analysis bearing steel, through-hardened in the Messinger heat treating plant. The rugged bronze cages contribute importantly to the long life and efficiency of these reliable bearings, particularly at high speeds.

Messinger Radial Roller Bearings are available in the following standard types and combinations: Plain; Self-Aligning With Adapter; Self-Aligning Without Adapter; Combination Radial and Thrust Bearing; Combination Radial and "X" Bearing. All are designed to carry extremely heavy loads with less space and weight. Standard sizes range from 4" I.D. to 60" I.D. Special types and sizes can readily be designed.

Radial Roller Bearings are just one of many types of bearings developed by Messinger to provide new measures of precision, compactness and long life. Engineering consultation invited, without obligation.

MESSINGER BEARINGS, Inc.

ROLLER AND BALL BEARINGS — *FEATHERWEIGHT TO HEAVYWEIGHT*

D STREET ABOVE ERIE AVE. • PHILADELPHIA 24, PA.

"Smoothing Industry's Pathway for Nearly Half a Century"

Circle 560 on Page 19

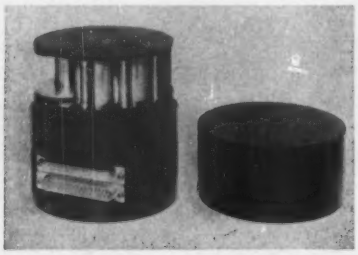
through the angle movement smoothly and easily. Control is as effective on the linoleum-covered steel top as it is on the metal-edge, all-basswood top. **Mayline Co. Inc.**, Sheboygan, Wis.

Circle 789 on Page 19

Miniature Tape Recorder

records 1 to 14 channels of data

Miniature magnetic tape recorder, designated Model TR-1875, simultaneously records 1 to 14 channels of data, from tests conducted under severe environmental and extremely limited space conditions, with a capacity of 150 ft of 1-mil polyester instrumentation tape, providing up to 16 minutes recording. Small, lightweight unit measures 4¼ in. in diam and 4¾ in. long; it weighs less than 3½ lb with full load of tape. Wow and flutter under static conditions are less than 1 per cent. All rotating shafts are supported by stainless-steel ball bearings. Other features are in-line reels, precision tape guides, minimum unsupported length of tape, and precision gear drive. Four tapped holes are provided for mounting purposes on the standard unit, with other mounting configurations available upon request. **Areo Data Mfg. Co.**, 12780B Western Ave., Garden Grove, Calif.

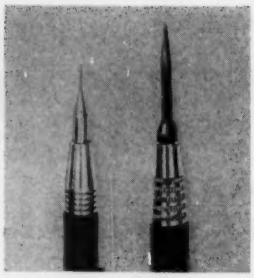


Circle 790 on Page 19

Lead Pencil

produces thin lines which never vary in width

Leroy 020 pencil holds leads 0.02 in. in diam which wear down evenly, assuring crisp, thin lines which never vary in width. Packaged in a plastic case, each pencil comes with a dispenser containing 24 leads.



Extra dispensers are available singly in packages of twelve. **Keuffel & Esser Co.**, Third & Adams Streets, Hoboken, N. J.

Circle 791 on Page 19

X-Y Recorder

requires only 17½ in. of vertical space

Rack-mounted, precision X-Y recorder, Autograf Model 2DR, draws cartesian co-ordinate curves automatically from two related sources of dc electrical information. It also plots one variable against time, accepts ac input data on either or both axes, and operates directly from a variety of Autograf accessories. Mounted flush with the rack,

The BIGGEST SCOOP in AIR PUMPS!

LEIMAN

CURVED VANES SCOOP UP MORE AIR

-- provide high capacity with slower speeds and less wear

Four curved vanes scoop up large volumes of air—provide 2 to 3 times more air space. Mounted on easy-action hinges to assure perfect contact with cylinder walls by centrifugal force. Vanes and cylinders made of durable cast iron (no composition). Hone themselves to hard, glassy smoothness to assure leak-proof seal and reduce frictional wear. Negligible wear is automatically taken up by rotating vanes.

SEE OUR CATALOG IN SWEET'S FILE

Write for new catalog showing construction, types, sizes and specifications, plus Application Book containing many "how-to-do-it" blueprints.

Leiman Air Pumps maintain new-pump efficiency and fully-rated vacuum or pressure for the life of your equipment, with little or no maintenance or repair. Fewer moving parts—no gaskets or packing—no composition vanes to wear out or renew. Pulseless airflow—every pump tested. Many models and sizes to meet your needs. Over 70 years' air engineering at your service on any design or application.

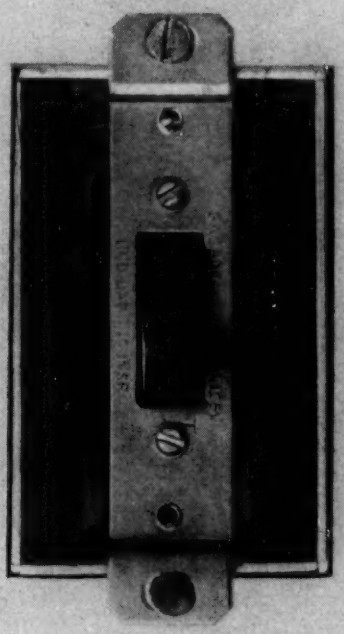
LEIMAN Rotary Positive AIR PUMPS

Vacuum to 29.9" Hg. Pressure to 20 p.s.i.g. Volume to 162 c.f.m.

LEIMAN BROS., INC., 158 Christie St., Newark 5, N. J.

Established 1889

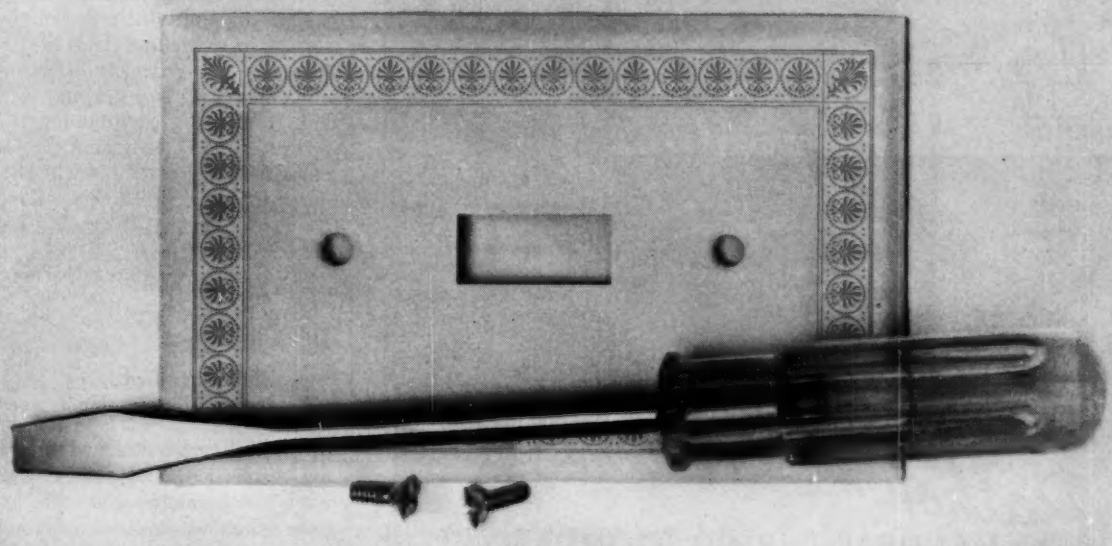
Circle 561 on Page 19



The switch is to decorated Beetle® Urea Plastic. Now you can mold multi-colored decorations into switch plates, stove hardware, business machine keys, temperature indicator knobs, electrical appliance housings, and countless other products—and maintain production economy! By incorporating a patterned, resin-impregnated foil during the molding process, you avoid costly after-decoration. The pattern becomes part of the molded Beetle Urea plastic. It won't chip off, scratch off or wear off. And you still enjoy these proven Beetle plastic advantages: resistance to detergents, oils and grease; arc-resistance; track-resistance; good dielectric strength; surface hardness; stain resistance; wear-resistance; unlimited range of colors. Write for complete information or call your local Cyanamid representative.

AMERICAN CYANAMID COMPANY CYANAMID PLASTICS AND RESINS DIVISION

Wallingford, Connecticut. Offices in: Boston • Charlotte • Chicago • Cincinnati • Cleveland • Dallas • Detroit • Los Angeles • Minneapolis • New York • Oakland • Philadelphia • St. Louis • Seattle • In Canada: CYANAMID OF CANADA LIMITED, Montreal • Toronto



When COMPACTNESS is IMPORTANT..

SPECIFY Pathon HYDRAULIC CYLINDERS

1 The Pathon single screw thread attaching method gives you extra compactness, low stress concentration, and will withstand greater shock loading.

2 Adequate space between the bearing points gives you increased bearing and rod seal life, reduced power eating friction.

3 The head seal in all Pathon Cylinders is a true static seal, assuring you longer life in operation.

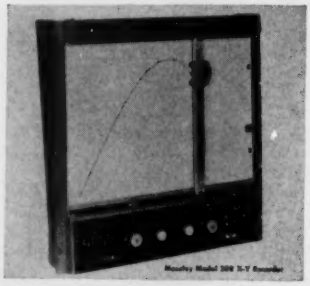
4 Pathon Cylinders have fewer parts, are easy to assemble, disassemble.

5 With Pathon Cylinders you have an extremely wide range of mounting types available to provide almost any mounting position you might want.

Write for further information today.

Pathon Hydraulic Cylinders are available in 1000—2000—3000 PSI and Low Pressure to 200 PSI

Pathon
MANUFACTURING COMPANY
3823 PACIFIC AVE., CINCINNATI 12, OHIO



unit requires only 17½ in. of vertical space. It is 19 in. wide and 6½ in. deep. Operating controls are located on an engraved sloping panel across the front of the instrument. DC input voltage ranges are in 16 calibrated steps from 0.5 mv per in. to 50 v per in. on each axis. AC input ranges are from 0.1 to 20 v per in. in eight calibrated steps on each axis. Model features a built-in vacuum paper hold-down, and has a pen speed of 20 ips for each axis. **F. L. Moseley Co.**, 409 N. Fair Oaks Ave., Pasadena, Calif.

Circle 792 on Page 19

Drafting Templates

new line consists of standard and specialized units

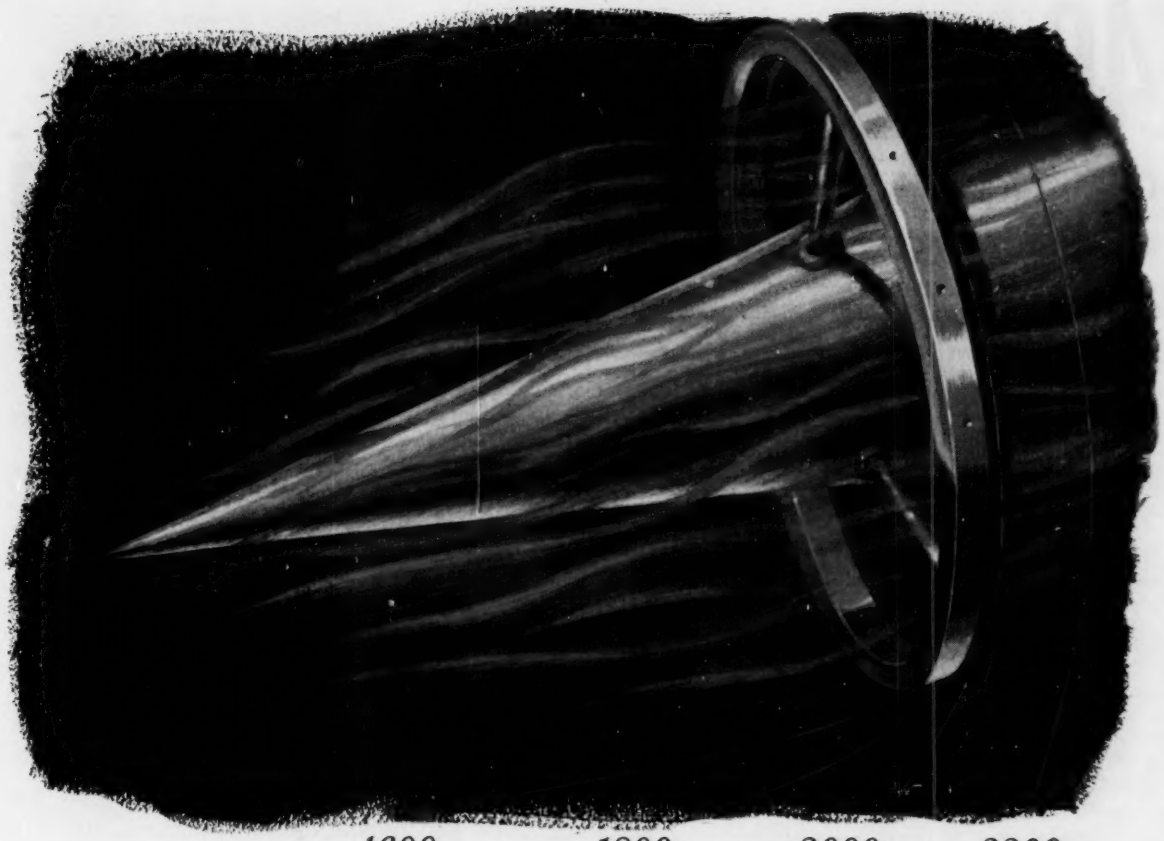
Consisting of 18 individual templates, new line is designated Speedraft. Made of high-quality transparent plastic, templates cover a wide range of standard symbols and figures, circles, squares, triangles, and ellipses in graduated sizes and scales. Line also includes templates for use in specialized fields of drawing, such as electrical and electronic, and ductwork for heating, ventilating, and air conditioning. All apertures are precision-cut individually for accuracy, with allowances for pencil thickness. **Keuffel & Esser Co.**, Adams & Third Streets, Hoboken, N. J.

Circle 793 on Page 19

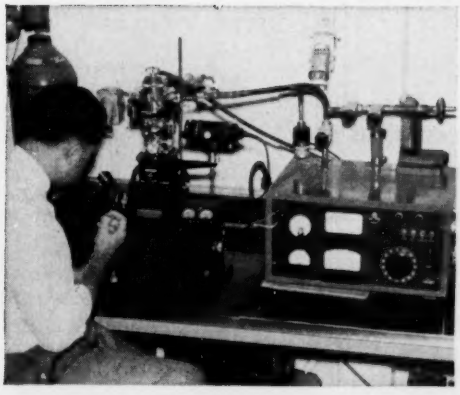
Lighting Device

provides magnified fluorescent illumination

Magniflex lamp is designed for drafting, inspection, and fine assembly work in laboratories and other locations wherever precision and accuracy are essential. Cool, shadow-free illumination that minimizes



Cutting back the Thermal Thicket



Solving high-temperature problems through research is part of Haynes Stellite's complete metallurgical services. This metallograph is used to observe metals at 2200 deg. F.

The great strength and high scaling resistance of HAYNES alloys at temperatures of 2000+ deg. F. are providing long service life in the hottest areas of jet engines. Flame holders, flame steps and afterburners are some of the hot spots where the properties of HAYNES high-temperature alloys are helping combat burnout, erosion, and stress in the jet, ramjet, missile, and rocket fields.

There are twelve HAYNES high-temperature alloys to choose from, formulated to handle virtually any heat condition. Among them: HASTELLOY alloy X with remarkable resistance to oxidation up to 2200 deg. F. HAYNES alloy No. 25 that resists stresses, oxidation, and carburization up to 2000 deg. F. And HASTELLOY alloy R-235, outstanding in the 1500 to 1750 deg. F. range. All are readily available.

HAYNES
ALLOYS
HAYNES STELLITE COMPANY
Division of Union Carbide Corporation
Kokomo, Indiana

UNION CARBIDE

Address inquiries to Haynes Stellite Company, 420 Lexington Avenue, New York 17, N. Y.

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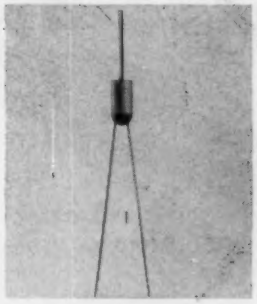

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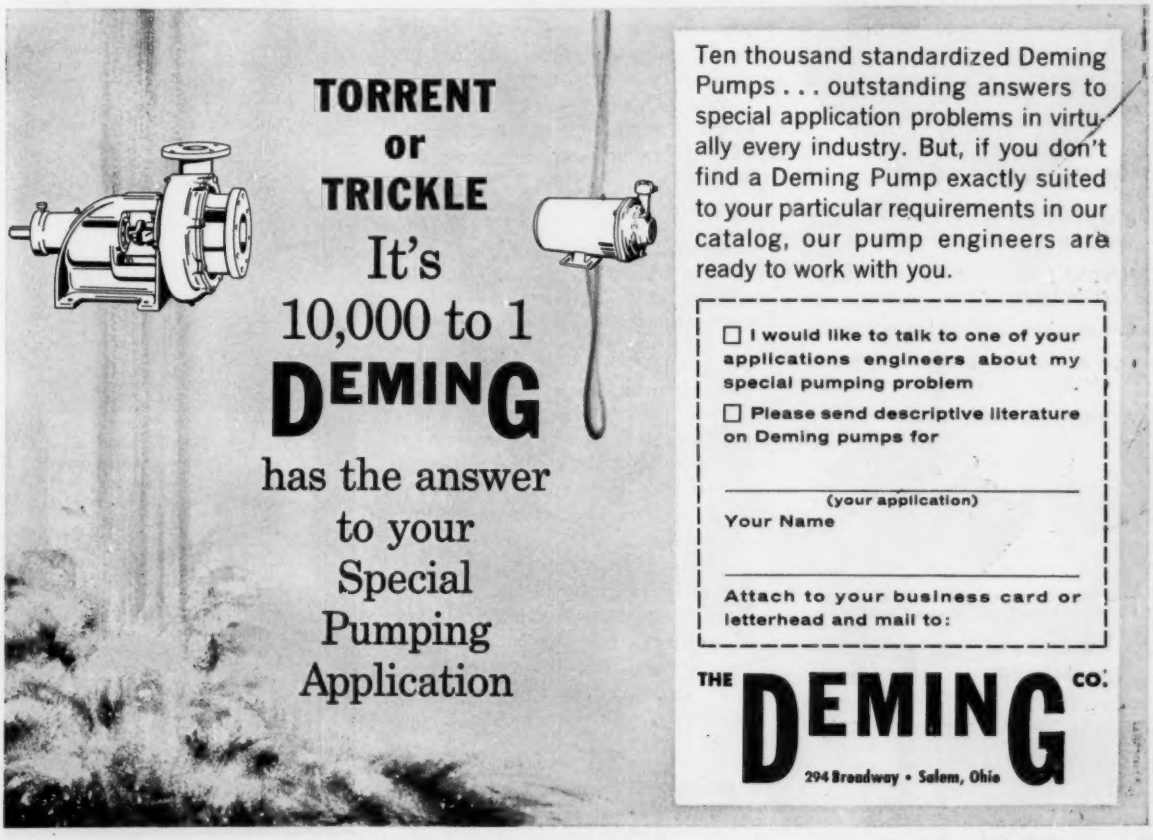
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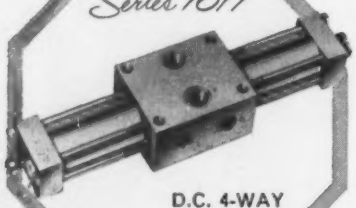

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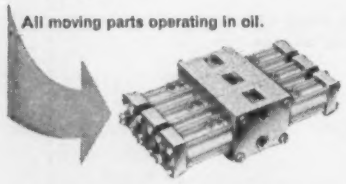

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THE ENGINEER'S Library

Recent Books

Linear Circuits: Part 1, Time-Domain Analysis; Part 2, Frequency-Domain Analysis. *By R. E. Scott, professor of electrical engineering, Northeastern University; two volumes, 510 and 418 pages respectively, 6¼ by 9¼ in., clothbound; published by Addison-Wesley Publishing Co. Inc., Reading, Mass.; available from* MACHINE DESIGN, *$6.75 for each volume.*

Part 1 deals with fundamental laws of electric-circuit theory, elements of network topology, mesh currents and node voltages, and methods for solving one-terminal-pair and two-terminal-pair problems. Also covered are transients in simple circuits, signal analysis in time domain, and elements of convolution theory.

Part 2 covers steady-state ac-circuit theory, and Fourier and Laplace transforms. Sharp distinction is made between time-domain circuits and frequency-domain circuits in presenting steady-state ac-network theory. Also, much attention is given to techniques of vector (phasor) algebra because of their importance in analyzing electrical circuits.

Advanced Dynamics for Engineers. *By G. M. Smith and G. L. Downey, associate professors of engineering mechanics, University of Nebraska; 354 pages, 6¼ by 9¼ in., clothbound; published by International Textbook Co., Scranton 15, Pa.; available from* MACHINE DESIGN, *$12.00 per copy postpaid.*

Emphasis is placed on derivation and solution of differential equations of motion. Vector analysis is used as a rigorous and efficient method of analysis.

Topics include kinetic and potential energy, impulse and momentum, Euler's equations, periodic motion of systems, Lagrange's equations, Fourier series, Hamilton's principle, and orthogonality of principal modes.

Principles of Feedback Control. *By C. H. Wilts, professor of electrical engineer-*

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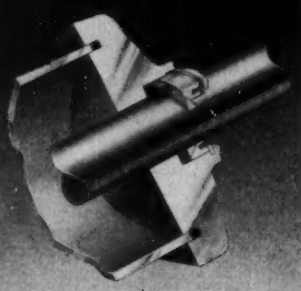

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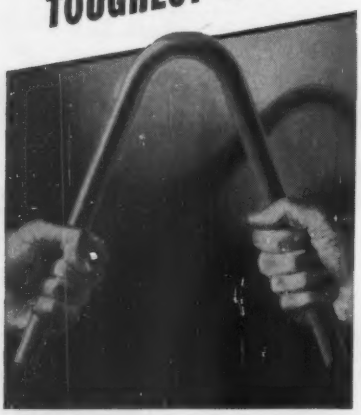

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ing, California Institute of Technology; 271 pages, 6¼ by 9¼ in., clothbound; published by Addison-Wesley Publishing Co. Inc., Reading, Mass.; available from MACHINE DESIGN, *$8.75 per copy postpaid.*

Analytical methods used in design of feedback systems are rigorously treated. Main theme is the stability problem.

Attention is given to fundamental aspects of the stability problem, to the Routh-Hurwitz and Nyquist tests, to generalized concept of a root locus, and to creation of a satisfactory degree of relative stability in systems that are unstable. Frequency-response and root-locus points of view are employed in alternate solutions of the problem.

Engineering and Technical Conventions —1961. *41 pages, 8½ by 11 in., paperbound, stapled; published by Deutsch & Shea Inc., 230 West 41st St., New York 36, N. Y.; $4.00 per copy.*

This advance listing of engineering and technical meetings and conferences to be held in the U. S. contains data on almost 700 state, regional, and national meetings. Listings of some meetings through 1965 are included.

Association Publications

Welding Metallurgy. *Edited by Arthur L. Phillips; 114 pages, 6 by 9 in., paperbound; published by American Welding Society, 33 West 39th St., New York 18, N. Y.; $2.00 per copy.*

This pocket-size booklet is a condensed version of the Welding Handbook and contains information on ferrous and nonferrous welding metallurgy. Fundamentals of welding metallurgy are covered: Mechanical properties of metals, structure of metals, factors affecting weldability, temperature changes in welding, and others.

Steel Castings Handbook. *Edited by Charles W. Briggs; 670 pages, 6¼ by 9¼ in., clothbound; published by Steel Founders' Society of America, 606 Terminal Tower, Cleveland, Ohio; $5.50 per copy.*

This handbook is an extensive revision of the 1950 edition, and contains comprehensive information on the technology of steel castings. Physical and mechanical properties, tolerances, fundamentals of

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Circle 571 on Page 19

How adapters affect "V" packing performance

The widespread popularity of "V" type packings is largely due to their versatility. For low pressure applications, a single "V"—with male and female adapter—may be sufficient. A set, incorporating many "V's", can withstand pressures well over 50,000 psi. They are used in cylinders (inside packed) and on rods (outside packed).

The overall performance, both sealing efficiency and service life, however, is largely dependent on the adapters which support the packings —and primarily on the female adapter because it supports the entire set. Excessive friction, packing extrusion, short service life and failure to properly seal can all result from adapters that are oversize, undersize, or made from materials not suited to the application.

Common Adapter Materials

Adapters are usually made of metal, phenolics, hard homogeneous rubber, fabricated rubber or leather. Each material has its merits and its limitations. In this group there is a range from hard, non-compressible materials to those that are softer and compressible.

What The Female Adapter Must Do

As we said earlier, the female adapter supports the entire set. But that's only part of its job. It must be hard enough to prevent extrusion of the "V" under pressure. Yet it must be soft enough to compress without fracturing. It must "breathe"—compress and flow radially under pressure then recoil when pressure is reduced thereby bridging the metal clearance.

Since "V" packings are in the category of "lip" type packings, their sealing action is due to the force of the actuating pressure expanding the packing. As a result of this "breathing" action, friction on the return stroke is negligible.

Adapter Material Selection

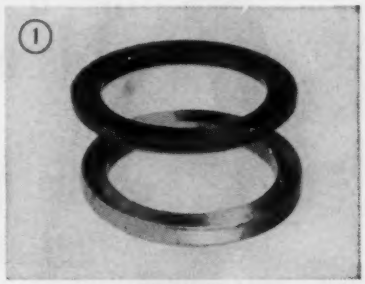
Now to get back to adapter materials. Metal, usually brass or bronze, is hard and inflexible. It can be machined so that the clearance is held to a minimum but it cannot breathe with the packings. Excessive friction and wear usually result.

Phenolic adapters are only slightly better. They "breathe" very little and at high pressures often fracture.

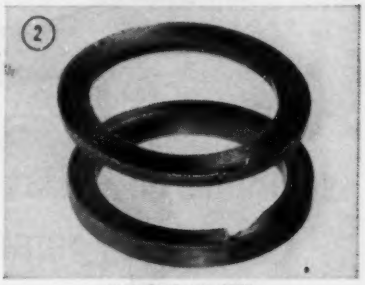
Hard homogeneous rubber, fabricated rubber or leather adapters are superior to both metal and phenolics. This is because these materials are compressible—they will "breathe" with the packing thus bridging the clearance and eliminating extrusion without unnecessary friction.

Homogeneous rubber adapters should be of about 55 Durometer on the "D" scale, fabricated rubber should be a fairly hard texture, and leather adapters are usually impregnated with a hard wax.

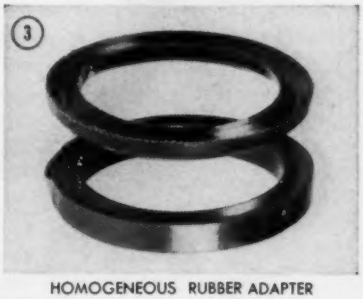
Houghton, the only manufacturer of both packings and fluids for hydraulics, has widespread experience in packing design, application and performance. For unbiased recommendations and help in improving packing performance, write E. F. Houghton & Co., 303 W. Lehigh Avenue, Philadelphia 33, Pa.



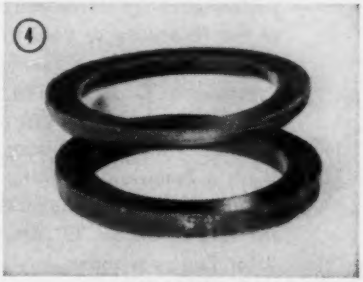
METAL ADAPTER



PHENOLIC ADAPTER



HOMOGENEOUS RUBBER ADAPTER



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steel-casting design, applications, welding, machinability, heat-treatment principles, and manufacture are thoroughly covered. Appendix includes engineering tables on various compositions of steels and a summary of steel-casting specifications.

Progress in Powder Metallurgy—Volume 16—Proceedings of the Sixteenth Annual Meeting of the Metal Powder Industries Federation. *215 pages, 8¼ by 9¾ in., clothbound; published by Metal Powder Industries Federation, 60 East 42nd St., New York 17, N. Y.; $10.00 per copy.*

New materials, properties, application of powder-metallurgy methods, testing, process controls, and outlook for powder metallurgy were general areas of discussion. Specific topics included in the 19 papers are heat-treatable steel-bonded carbides, sintered nickel steels, application of stainless-steel powder metallurgy, aircraft superalloys by powder metallurgy, low-temperature impact strength of sintered steels, and evaluation of magnetic materials.

1960 Proceedings—Special Technical Conference on Nonlinear Magnetics & Magnetic Amplifiers. *348 pages, 8½ by 11 in., paperbound; published by American Institute of Electrical Engineers, 33 West 39th St., New York 18, N. Y.; $7.00 per copy.*

General subject of nonlinear magnetics, and specialized fields of computer magnetics, magnetic amplifiers, and combination devices were covered. Specific topics of the 27 papers include magnetic amplifiers as magnet supplies, programmed time-ratio control techniques, behavior of magnetic materials under extreme environmental conditions, and self-propagating core logic.

Manufacturers' Publications

Transistor Manual—Fifth Edition. *Edited by Semiconductor Products Dept., General Electric Co.; 329 pages, 6 by 8¾ in., paperbound, plastic-ring binder; published by General Electric Co., Kelley Bldg., Liverpool, N. Y.; $1.00 per copy.*

Specifications, applications, and circuits for transistors are presented. This fifth edition contains new chapters on tunnel-diode theory and switching circuits, tunnel-diode amplifiers, feedback and servo ampli-

fiers, and test circuits. Chapters on silicon-controlled rectifiers, power supplies, and transistor and rectifier specifications have been revised and expanded.

RCA Photosensitive Devices and Cathode-Ray Tubes. *36 pages, 8½ by 11 in., paperbound; published by Electron Tube Div., Radio Corp. of America, Harrison, N. J.; $0.50 per copy.*

Technical information covers RCA phototubes, photocells, image-converter tubes, camera tubes, storage tubes, cathode-ray tubes, and special-purpose kinescopes. Data include dimensions, basing diagrams, ratings, operating values, and typical and recommended uses.

Government Publications

OTS Technical Reports. Copies of reports listed below are available from Office of Technical Services, U. S. Dept. of Commerce, Washington 25, D. C.

PB 161719. Friction and Wear at Elevated Temperatures. By Ernest Rabinowicz, Massachusetts Institute of Technology; 21 pages, 8¼ by 10¾ in., paperbound, stapled; $0.75 per copy.

A new high-temperature friction apparatus was constructed for sliding experiments on various materials at temperatures to 2000 F, in controlled atmospheres, and at various speeds. Results of tests are discussed theoretically in terms of surface energy.

PB 161723. Mechanical Properties of Selected Alloys at Elevated Temperatures—Part II: Design Criteria of Silicon Carbide. By Harry A. Pearl, John M. Nowak, and Harry G. Deban, Bell Aircraft Corp.; 121 pages, 8¼ by 10¾ in., paperbound; $2.75 per copy.

Nondestructive tests were conducted to determine density uniformity, dynamic modulus, x-ray diffraction under transverse load, electrical resistivity, and internal friction. A theoretical analysis is presented on effect of specimen size, surface finish, and methods of loading on strength properties.

PB 161733. Investigation of Elastic and Thermal Properties of Carbon-Base Bodies. By S. Mrozowski, J. F. Andrew, N. Juul, J. Okada, H. E. Strauss, and D. C. Wobschall, University of Buffalo; 84 pages, 8¼ by 10¾ in., paperbound, stapled; $2.25 per copy.

Elastic and thermal properties of four basic types of carbon were investigated: Soft filler and soft binder, soft filler and hard binder, hard filler and soft binder, and hard filler and hard binder. Results are tabulated.

PB 161761. Mechanical Properties of Selected Alloys at Elevated Temperatures. By Harry A. Pearl, George F. Kappelt, and Edmund J. King, Bell Aircraft Corp.; 250 pages, 8¼ by 10¾ in., paperbound; $4.00 per copy.

Six alloys—AM 355, PH15-7Mo, HK31-H24, A286, Udimet 500, and Inconel X—were subjected to tension, compression, bearing, and shear stresses. Exposure times were ½, 10, 100, and 1000 hr. Test temperatures were room temperature, 600 F, 1000 F, 1200 F, 1500 F, and 1700 F.

SB 413. Beryllium (1945-1960). 19 pages, 8 by 10¼ in., paperbound, stapled; $0.10 per copy.

This selective bibliography on beryllium research covers forging, vacuum melting and casting, spectrochemical inspection, thermal expansion, magnetic properties, metallographic preparation, and corrosion control. Government-owned patents available for license are also listed.

SB 414. Columbium and Tantalum. 14 pages, 8 by 10¼ in., paperbound, stapled; $0.10 per copy.

Strain-rate sensitivity, creep behavior, high-temperature mechanical properties, and other reports on columbium and tantalum metals and alloys are covered in this selective bibliography. Government-owned patents available for license are also listed.

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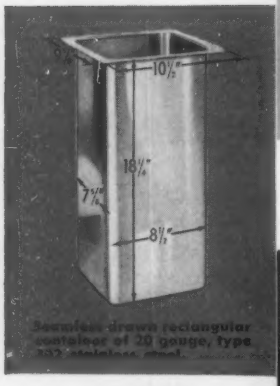
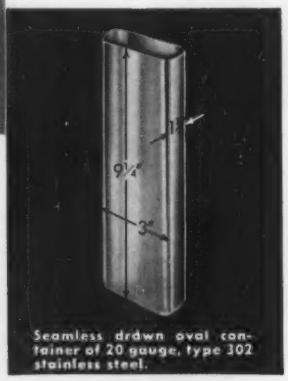


Seamless drawn rectangular container of 20 gauge, type 302 stainless steel.



Seamless drawn oval container of 20 gauge, type 302 stainless steel.

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Professional Viewpoints

. . . scanning the field for ideas . . .

To the Editor:

We note with interest your description of the nonrecirculating ball nut assembly as featured in "Scanning the Field for Ideas" (MACHINE DESIGN, Dec. 8, 1960).

Please note that this is not a sound design. The balls have to skid drastically when the actuator screw rotates. No doubt you will agree that this condition—balls skidding under load in an annular groove—is extremely poor design practice.

When you feature an item, you also strongly imply that this is a design whose merits you approve. Your implied endorsement of this poorly engineered device disappoints us.

—H. W. DEUTSCH
Manager
Special Products Div.
Scully-Jones and Co.
Chicago, Ill.

We agree—the balls must skid as well as rotate—and this is not generally considered to be good design practice. But the nonrecirculating ball arrangement does provide a definite design advantage—it inherently prevents load feedback force from turning the actuator screw. This is probably the one time when the vice of higher friction becomes a virtue.

In the selection of a component for use in a given situation, good design practice dictates that the designer consider all the factors involved and then arrive at the optimum solution—usually a compromise among the many conflicting factors.

For this reason, it is impossible for us to arbitrarily place all design ideas in a black or white category of bad or good.

In selecting items for use in "Scanning the Field for Ideas," we eliminate the ones that are obviously black. For example, our requirements that the item be in production or in working prototype form are intended to screen out the "inventors' ideas" which exist only on paper. A rigorous analysis of our "Ideas" would, no doubt, reveal limitations in every design or application.

Thus, our use of an idea in this section can hardly be considered as an endorsement for all situations. We agree with your premise, but we disagree with the conclusion that we've approved the design or endorsed the product.

—ED.

. . . rack teeth for exact stroke . . .

To the Editor:

I have read with interest Mr. Eikelboom's article, "Rack Teeth for Exact Stroke," (MACHINE DESIGN, Nov. 24, 1960) and wish to compliment him for bringing this matter to the attention of the trade. It again emphasizes the flexibility of the involute system which can also be applied to the generating of the special

rack teeth required for his case.

When a Fellows rack shaper is used, the same *standard cutter* can be used for generating standard racks and also for producing racks of special circular pitches and special pressure angles by simply altering the change-gear combination for a desired circular pitch, p.

Assume a 15-tooth cutter of diametral pitch $P = 2$,

$$p = \frac{\pi}{2} = \frac{355}{113(2)}$$

For the benefit of those who are not familiar with the value of the fraction 355/113, it should be noted that it can be used for π and that it is correct to within 3 in the seventh decimal place as follows: 355/113 = 3.1415929 instead of 3.1415926. It should also be noted that since 355 can be factored (71)(5) the result is a convenient gear ratio of (71/113)(5/1).

The change gear formula for a number 3-60 rack shaper (3-in. face width and 60-in. long rack) is:

$$\frac{AC}{BD}\left(\frac{N}{15}p\right) = \frac{1}{1}$$

where N = the number of teeth in the cutter.

For a 15-tooth, 2 diametral-pitch cutter

$$\frac{AC}{BD}\left[\frac{15}{15}\,\frac{(355)}{(113)(2)}\right] = \frac{1}{1}$$

$$\frac{AC}{BD}\left[\frac{71(5)}{113(2)}\right] = \frac{1}{1}$$

$$\frac{2}{5}\left(\frac{113}{71}\right)\left(\frac{71}{113}\right)\left(\frac{5}{2}\right) = \frac{1}{1}$$

Therefore, $A = 30$; $B = 75$; $C = 113$; $D = 71$.

If $p = 48/30 = 1.6$,

$$\frac{AC}{BD}\left[\frac{15}{15}\left(\frac{48}{30}\right)\right] = \frac{1}{1}$$

$$\frac{40}{40}\left(\frac{30}{48}\right)\left(\frac{48}{30}\right) = \frac{1}{1}$$

Thus, $A = 40$; $B = 40$; $C = 30$; and $D = 48$

With this combination of gearing, perfect compensation is effected both as to circular pitch and pressure angle. As a matter of fact, the calculation of the rack is only necessary for record purposes and if a record of the rack dimensions is not required, a simple change-gear calculation solves the entire problem.

—J. L. WILLIAMSON
Engineering Consultant
The Fellows Gear Shaper Co.
Springfield, Vt.

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"As industry has advanced technologically, the way is opened for professional engineers and scientists to use increasingly large numbers of persons who have had part of the basic training of the engineer or scientist, but who for their roles do not need all of it."—ALGO D. HENDERSON, *Professor, University of Michigan, Ann Arbor, Mich.*

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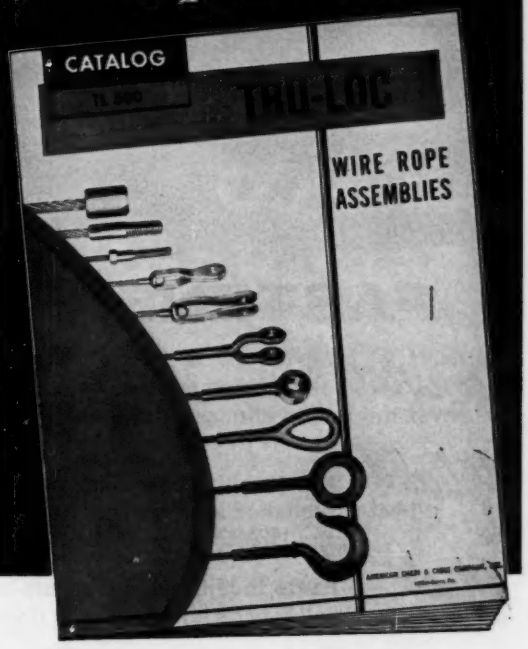

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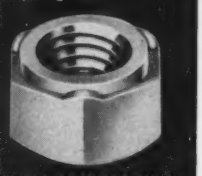
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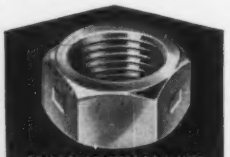

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NOTEWORTHY

Patents

Combination Full-Flow and Bypass Filter

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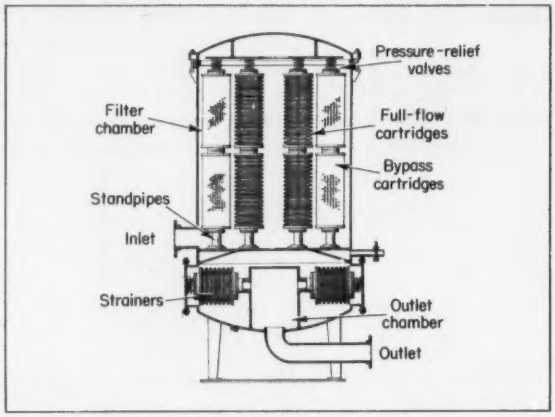
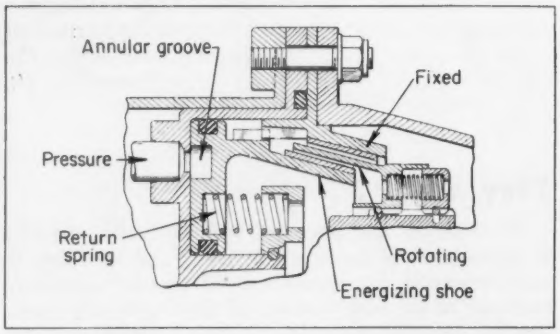


is warmed and becomes sufficiently free flowing to pass through the full-flow system, the relief valves close. The warm fluid flowing around the bypass cartridges heats the filter elements until they are fully operative. About 5 to 10 per cent of the total fluid is filtered by the bypass system at all times, while the rest flows through the full-flow system. *Patent 2,966,269 assigned to Hoffman-Allen Corp., Springfield, Mo., by Albert S. Allen.*

Hydraulic-Pneumatic Cone Brake

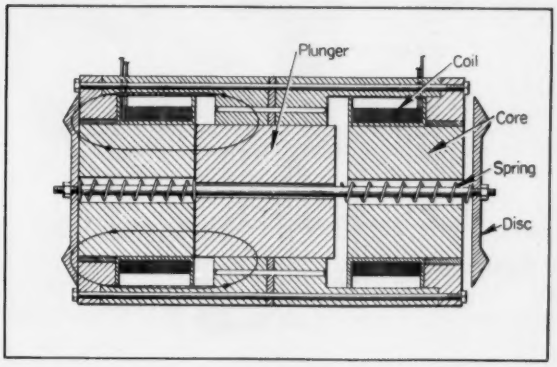


Pressure-actuated concentric conical friction surfaces can handle shaft speeds up to 8000 rpm and are un-

affected by ambient pressure or temperature. A rotating conical member turns between two other similar members, one of which is fixed, while the other is free to slide axially and serves as an energizing shoe. When fluid is forced under pressure into an annular groove in the energizing shoe, the rotating brake member is clamped between the nonrotating members. Since the pressure on the energizing shoe can be controlled, the brake can also serve as a clutch. Wear is automatically accommodated by the conical design. *Patent* 2,966,237 *assigned to Salisbury Corp., Los Angeles, Calif., by Louis C. Galleher.*

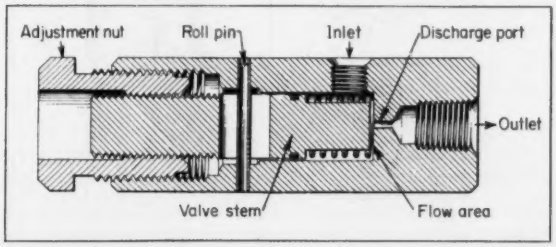
Fast-Acting Solenoid

A pair of spring-loaded magnetic discs in a solenoid minimize the delay between the time that the solenoid coil is energized, and the magnetic field is built up. When current is fed to one coil, the disc, core, and plunger are magnetized. As they are drawn tightly together, setting up a strong magnetic field, the return spring is compressed between the disc and plunger.



When this coil is de-energized and current is transferred to the other coil, the return spring snaps the plunger, core, and disc apart, while the plunger is almost immediately clamped to the other core to set up a new magnetic field. This field builds up quickly enough so that the disc does not bounce as it is clamped to the core. *Patent* 2,967,983 *assigned to Burroughs Corp., Detroit, Mich., by Ronald W. Danklefs.*

Temperature-Compensating Metering Valve



The size of the discharge orifice in a metering valve varies inversely with the temperature of the system fluid, insuring a constant flow rate through the valve. Fluid passes from the inlet port, to the space around

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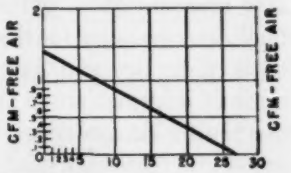

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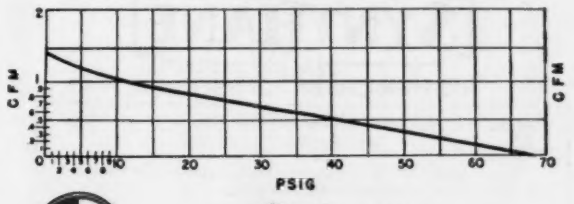

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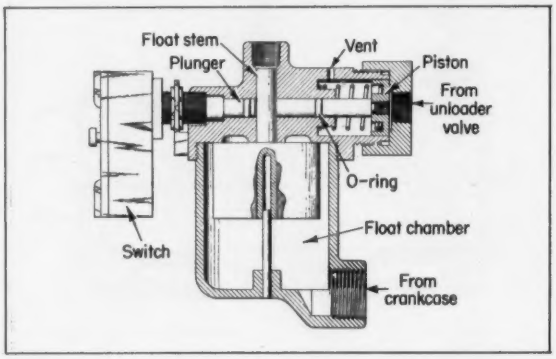
the valve stem, and into the flow area between the valve stem face and the valve body. The size of this area may be adjusted by means of a nut which controls axial movement of the valve stem. The stem is made of a material having a higher coefficient of expansion than the rest of the valve, so that variations in temperature cause the stem to expand or contract, varying the size of the flow area and thus controlling the amount of fluid admitted to the discharge port. Passage of any sizable foreign matter is prevented by the relatively narrow flow area. *Patent* 2,966,170 *assigned to Otis Engineering Corp., Dallas, Tex., by George M. Raulins.*

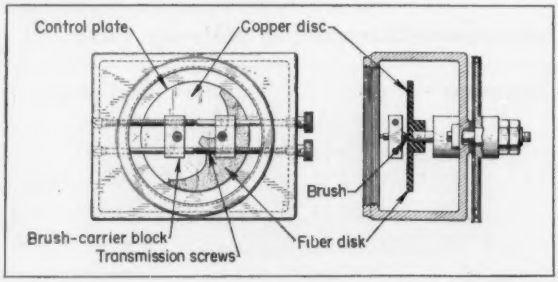
Pneumatic Safety Shutoff

Air flowing from the unloader valve of a compressor is used to shut the compressor off if the oil level falls to a predetermined danger point. Under normal conditions, air from the unloader valve flows by the piston and out through a vent. When the float-chamber oil level, which is the same as the level in the crankcase,



falls to a dangerous point the float stem drops. Air pressure on the crown of the piston then forces the piston rod against the plunger, actuating an electrical switch to shut off the compressor. *Patent* 2,966,295 *assigned to Champion Pneumatic Machinery Co., Princeton, Ill., by Frederick J. Rayfield Jr.*

Quick-Adjust Timing Control



A pair of translating screws permit instantaneous setting of a timing control which allows wide variation of time sequences. A pair of brushes are carried by threaded blocks and ride on a control plate with fiber and copper surfaces. When both brushes are in con-

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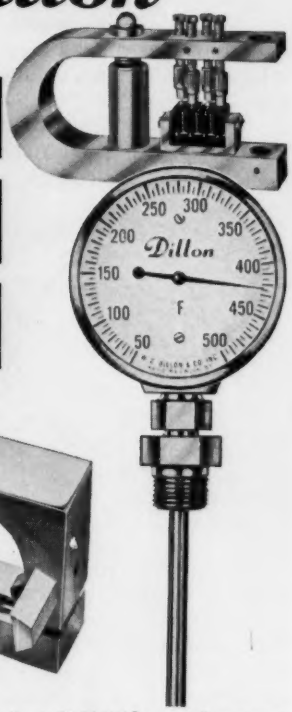

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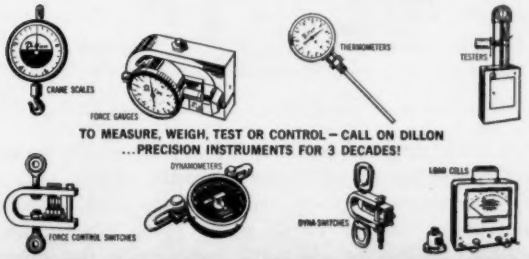

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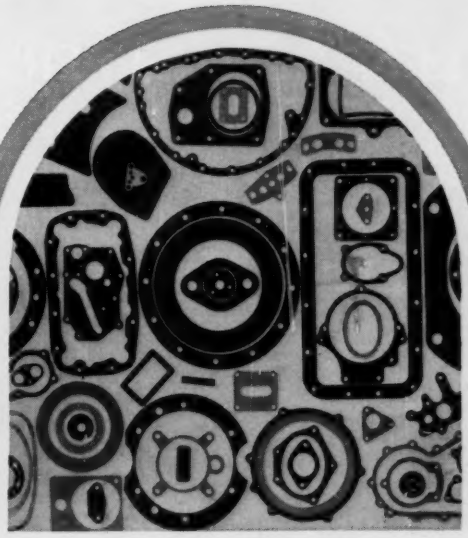

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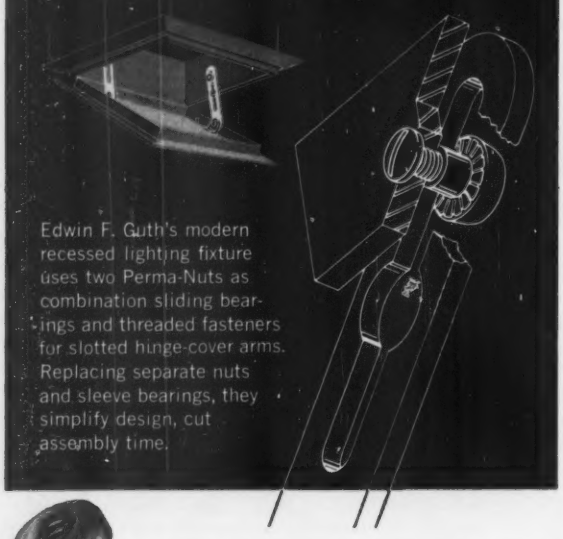

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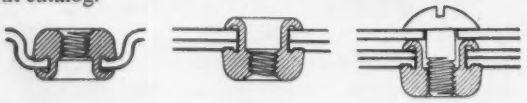

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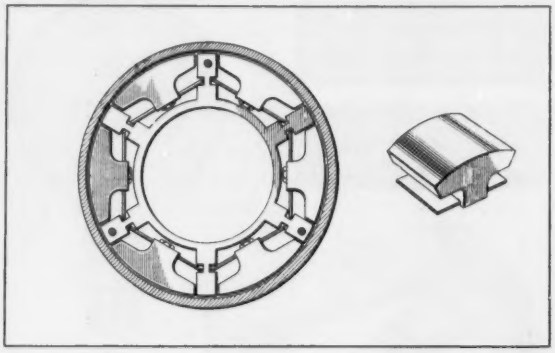
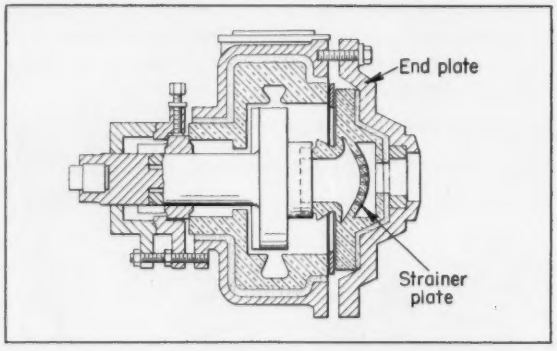
tact with the copper surface, a solenoid is energized; when one or both brushes are in contact with the fiber surface, the solenoid is de-energized. Thus the interval of time in which the solenoid is energized depends on the position of the brushes—the closer together the brushes, the longer the time interval. *Patent* 2,966,881 *assigned to Binks Manufacturing Co., Chicago, Ill., by Bruno E. Enssle.*

Unlined Centrifugal Clutch



The shoes in a centrifugal clutch are made of bronze, while the drum is made of gray cast iron. No linings are used. This combination provides satisfactory friction characteristics, and also eliminates checking of the drum, since more than 98 per cent of the heat generated by the system is absorbed in the shoes. A simple leaf-spring arrangement eliminates the possibility of damage or malfunction caused by foreign matter, since there are no bearing surfaces in the spring assembly. *Patent* 2,965,206 *assigned to Formsprag Co., Warren, Mich., by Rex E. Moule and Lyndoe E. Fairbanks.*

Contaminated-Fluid Centrifugal Pump



A porcelain-lined centrifugal pump for use in pumping contaminated or highly corrosive liquids uses a ceramic screen filter to remove large solid particles that might damage brittle pump parts. The strainer plate is concave for additional resistance to the impact of the system fluid. Size of the openings in the strainer may be gaged to the degree of filtration which is required. *Patent* 2,963,979 *assigned to Indiana General Corp. by Charles E. Eisenman, Clarence A. Brooks, Stephen Katransky, and Joseph J. Nemeth.*

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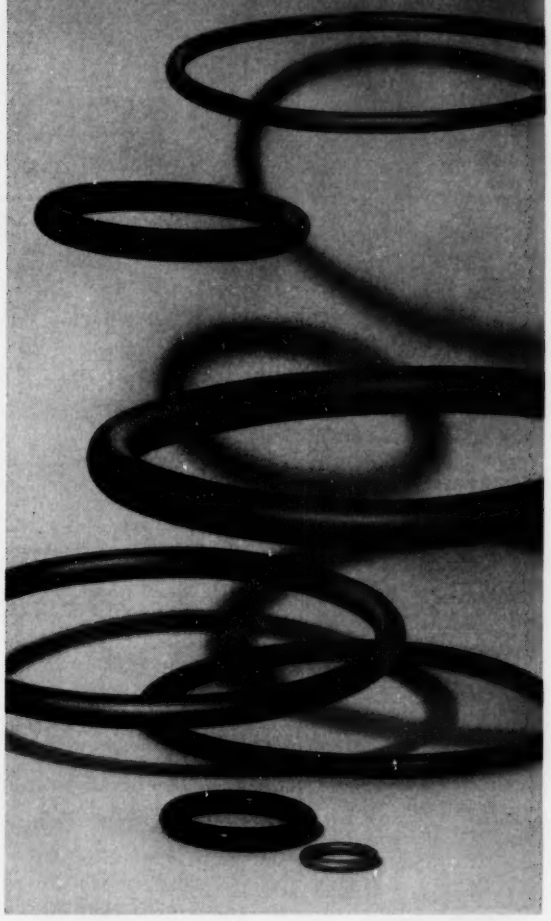

Stillman has an enviable reputation for reliability in the development and production of O-Ring seals for military and industrial applications. The most difficult sealing requirements are met with ease because of Stillman's long years as sealing specialists for military projects where precision and reliability are prerequisites. Stillman O-Rings are produced in a complete range of sizes and compounds for both static and dynamic sealing. These O-Rings have found complete acceptability for the most critical applications. Unusual compounds such as silicone and Viton are standard in Stillman O-Rings. Still more exotic compounds are coming from Stillman laboratories each day, to meet the increasingly complex demands of present-day technology.

For further information, write to:

STILLMAN RUBBER COMPANY

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Circle 583 on Page 19

DIALCO® OIL TIGHT INDICATOR LIGHTS

for heavy duty industrial applications

Mounts in 1" clearance hole
No. 104-3502-XP10-231

DISCS with **legends**, behind flat lenses, deliver specific messages.

NO OIL, WATER, DUST or FUMES CAN PENETRATE THE *Built in* BARRIERS

(Illust. approx. 60% actual size)

Mounts in 1" clearance hole
No. 103-3502-1331

Complete oil-tightness on the panel surface is assured by the use of *retained* oil-proof gaskets—plus gasketed lens assemblies in which the lens is *sealed* to its metal holder.

Designed for Severe Service: Heavy duty features include: One-piece solid brass bushing, solid brass lens holder, permanent-color glass lenses, high impact phenolic insulation, and rugged terminals.

Wide Range of Sizes: Series of units are available for mounting in clearance holes ranging from 11/16" up to 1-5/8" in diameter...with several lens styles in a choice of 7 colors... with *binding screw, soldering, or quick connect* terminals.

No. 125-410-1111

Mount in 11/16" clearance hole

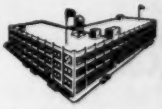
No. 125-1308H-1191 (high brightness Neon)

For Neon or Incandescent Lamps (with screw-base or bayonet-base): With Neon (including *high-brightness* types) DIALCO offers BUILT-IN RESISTORS (U.S. Pat. No. 2,421,321) for use on circuits of 105-125 V., and 210-250 V.; (simple external resistors are provided for all higher voltages).

Every assembly is available complete with lamp.

SAMPLES ON REQUEST—AT ONCE—NO CHARGE

Ask for Brochure L-200A.



Foremost Manufacturer of Pilot Lights

DIALIGHT CORPORATION

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Circle 584 on Page 19

You realize more **profits**

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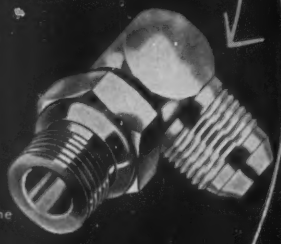
when using L & L's new hydraulic fittings

"CN"

- Will stop hydraulic fluid leakage
- Will reduce maintenance . . . assembly time

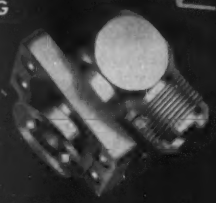


METERING AND SHUT-OFF VALVE

- Rated for 5000 psi pressures
- Choice of outlets
- Simple maintenance

FLANGE FITTING

- Designed for quick installation
- Eliminates pipe thread connections
- Choice of wide selection of outlets



Other outstanding features:

"CN"

- Eliminates stress in valves, elbows and tees
- Can be positioned 405°
- No need for sealing compounds
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- Hex sizes are small to permit close openings for valves and other component parts

Metering and Shut-off Valve

- Stainless Steel stem
- Adaptable to straight or angle valves with male pipe, female pipe or tube connections
- O-ring only replacement part needed
- Available in sizes—⅛" to ¾"

Flange

- Adaptable to solid and swivel tube, pipe or weld connections
- Can couple together to make unions or clusters

All fittings available in a wide range of shapes, sizes

L&L

"Specialists in Hydraulic Fittings"

L and L Manufacturing Company

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Circle 586 on Page 19

precision

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with metal insert hubs

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Also molded "Hexlok" pulleys, worm gears, ratchets, rollers, etc.

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From stock, cut tooth nylon rack with 14½° and 20° pressure angle. Pitch range 16 to 48, lengths to 24-in.

Write for sample and literature.

CLIMAX METAL PRODUCTS CO.

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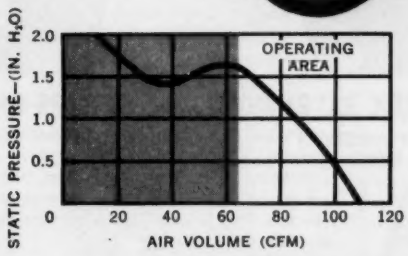
3" dia. x 3¼" long, 16 ounces



NEW VANEAXIAL

AC/DC UNIVERSAL BLOWER

Globe's VAX-3-GN Universal Blower gives you 110 cfm. free air, with a design point of 68 cfm. at 1.5" H_2O—on **either** 115 v.d.c. or 115 v.a.c., 60 cycle power. Other voltages can be supplied. Nominal speed is 14,000 rpm.

You can standardize on this extremely versatile blower for ground support and commercial electronic cooling. It's designed to meet MIL specs, having passed shock and vibration per MIL-E-5272. Production tooling makes this blower economical. Prototypes can be in your hands tomorrow (telephone BA-2-3741 for part no. 19A908); production orders normally delivered in a short time.

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with MULTI-MILLION CYCLE PERFORMANCE!

The DECCO 01 and 02 series, miniature solenoids have the same quality and performance standards as the well known standard size DECCO solenoids.

From silicon steel laminations to new, thirty-second coil replacement feature they incorporate the best in quality and engineering.

If you have a miniature solenoid application, the DECCO "0" series is the answer. Write for bulletin #581 for complete details.

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PETERBOROUGH, N. H.

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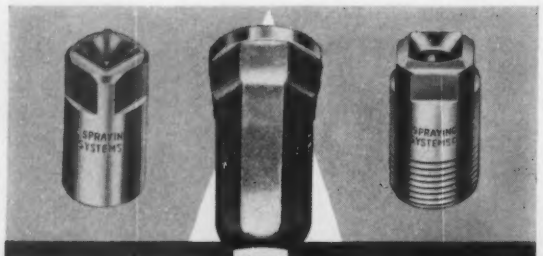
Circle 590 on Page 19



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SQUARE SPRAY *FullJet* SPRAY NOZZLES

For numerous multiple-nozzle applications, because the square spray patterns "fit together", here are nozzles that make possible uniform, complete coverage with fewer nozzles per manifold. This is the latest design in Spraying Systems' very complete line of FullJet nozzles in square and standard-circular spray patterns. For complete information write for Bulletin 105 and Catalog 24.

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AMERICA'S MOST COMPLETE LINE OF SPRAY NOZZLES

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IDEAS!
for heavy equipment designers

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- Standard transmissions customized to each application
- Wide variety of "engineered-to-order" transmissions
- Specifications (capacities, speeds, gear ratios) for heavy-duty applications
- Examples of single-speed, multiple-speed and right angle drive transmissions

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Please send my copy of "Cotta Heavy-Duty Transmissions" to

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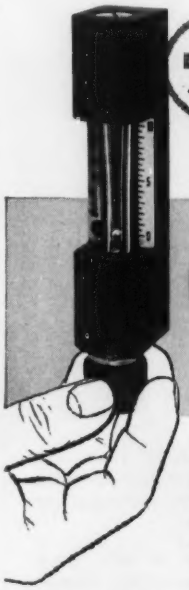

NEW PURGE ROTAMETERS *have stainless steel parts*

Fig. 1853 has anodized aluminum body, stainless steel parts. The Fig. 1855 is all stainless.

SK Purge Rotameters for indicating and manually controlling small flows are competitively priced yet give these advantages—stainless steel internal parts . . . positive back flow check valve . . . effective flow control valve . . . removable tube feature. Available with differential regulator for automatic control of purge rate of flow. Also supplied in lucite and Kel F. Write for new Bulletin 18P.

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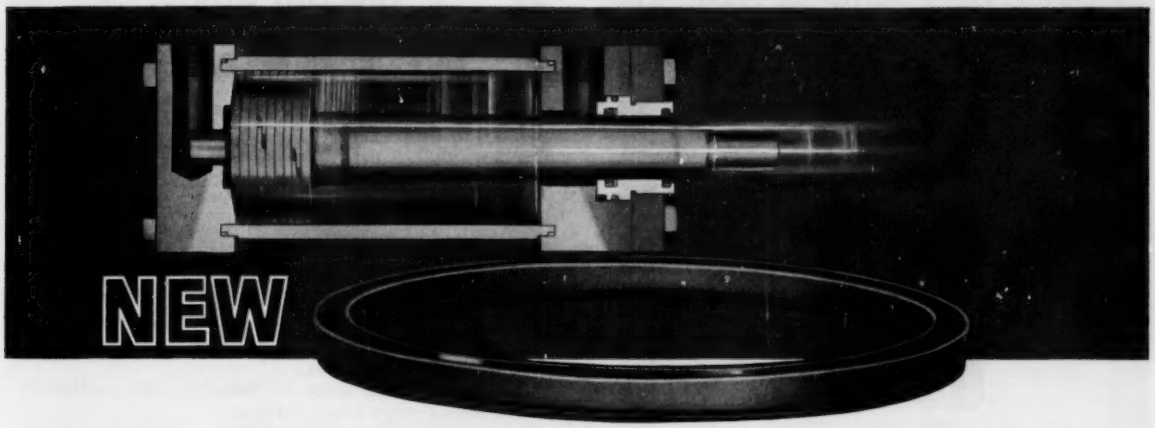
Circle 594 on Page 19

DURATON ROD SEAL IN HYDRO-LINE CYLINDERS



Here is a new opportunity to reduce machine downtime and costs caused by cylinder leakage or scoring: Hydro-Line's "Duraton" rod seal — exclusive durability formed from Viton®, guarded by backup washer of carbon-impregnated Teflon.

Leakproof seal is assured by superior resistance of "Duraton" rod seal-backup washer combination to abrasives, corrosives, and pressure. Retains effective resiliency at temperatures to 400°F and higher. Compatible with virtually all hydraulic fluids. Resists aging.

Iron-oxide-colored "Duraton" rod seals, Ebalon backup washers, and Viton wipers are standard on Hydro-Line Series N2 hydraulic cylinders to 5000 psi. See your Hydro-Line representative for details.

HYDRO-LINE

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5602 PIKE ROAD, ROCKFORD, ILLINOIS, manufacturers of: high- and low-pressure hydraulic cylinders • heavy-duty air cylinders • boosters • adjustable-stroke cylinders • dispensing cylinders • single-acting cylinders • rod end couplers

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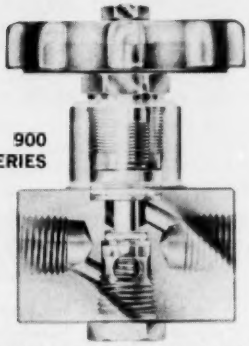
CIRCLE SEAL *HIGH PRESSURE* SHUTOFF VALVE *...LEAKPROOF Fingertip Operation*



0-6000 psi. ¼" pipe and ⅜" tube connections. 303 Stainless construction.

CIRCLE SEAL precision valves

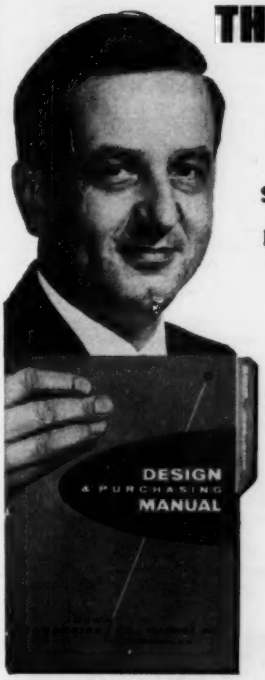
Unique design combines **positive** leakproof shutoff with full flow passages and freedom from wire drawing. Design of stem and seat permits simplified throttling of flow. Light fingertip operation actuates either a handwheel or toggle lever for rapid actuation. Unique and useful variations on the basic 900 Series configuration: • Right angle flow. • Integral Relief—combines relief valve function with shutoff permitting cylinder thermal pressure relief, etc. • Triport with one inlet and two outlets or one outlet and two inlets.

CIRCLE SEAL precision valves

CIRCLE SEAL PRODUCTS CO., INC.
2181 East Foothill Blvd.,
Pasadena, Calif.

Circle 596 on Page 19

LOOK TO THE MAN BEHIND THE MANUAL *before you buy bearings!*



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Eastern Regional Office
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HE'LL BRING YOU up to the minute on new developments not covered by our 150-page manual. An Instrument Ball Bearing Engineer, he'll help you select the type and size of bearing that will deliver top performance. Try him and see.

HE'LL SEND YOU our manual if you already don't own it. It belongs in the files of every qualified engineer, draftsman or purchasing agent.

NEW HAMPSHIRE BALL BEARINGS, INC.
PETERBOROUGH, N. H.

Circle 597 on Page 19

B5 *Local Mounted* **TEMPERATURE CONTROL**

TYPE B5

External Adjustment

KNOB AND DIAL

UNITED ELECTRIC's type B5 control allows temperature settings to be made by rotating a single turn knob and pointer against a calibrated dial. It is a compact, inexpensive, precision-built control designed for numerous applications including hot water tanks, internal-combustion engine cooling systems, boilers, degreasers, etc. Uncalibrated, internally adjusted versions of the type B5, designated type C7, are also available. Complete information on these and other local mounted controls may be had by requesting the *new* Catalog Section 100. Information contained in this new catalog will prove extremely helpful to all design engineers.

Calibrated Ranges	100° or 200° F. between 0° and 425° F. limits.
Thermal Assemblies	Various immersion lengths . . . liquid-filled seamless brass bellows operate by hydraulic action.
Switch Ratings	15 amps. at 115 or 230 volts AC, also 20 amps. or DC switches available on specification.
Switch Types	N.O., N.C., Double Throw, no neutral position.
Electrical Connection	To internally located terminal block by clearance hole in enclosure.
Size & Weight	4¼" x 1½" x 6⅛", weighs approx. 12 oz.
Mounting	For local mounting by ½" male NPT on immersion element, turning radius is 3⅜".
Enclosure	Aluminum case with black wrinkle finish.

UNITED ELECTRIC manufactures a complete line of temperature, pressure, and vacuum controls. Modified or custom-built units can be made to suit your specifications. Consult a UE application engineer today.

Write for Bulletin No. 2-1 for more data on the B5 control or request the new Catalog Section I which covers all UE local mounted units.

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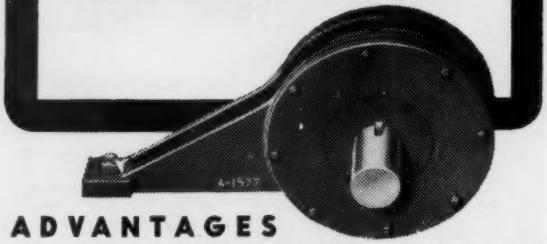
United Electric Controls COMPANY

SCHOOL STREET WATERTOWN, MASS.

GREATER TONNAGE PROTECTION AT LOW COST WITH . . . S-A TOTALLY ENCLOSED HOLDBACKS



ADVANTAGES

- Prevents disastrous reversal of heavily loaded belts during power failures.
- Engages without shock . . . Instantly holds . . . Instantly releases when power resumes.
- Eliminates feeder point flooding . . . protects men and equipment.
- Easily installed . . . Economical to purchase, operate and maintain.
- 2 7/16" to 12" bore sizes available.
- Stocked for immediate delivery.

S-A

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SPEEDWALK® PASSENGER CONVEYORS

SPHERICO® BEARINGS & ROD ENDS

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PLANTS LOCATED IN: LOS ANGELES, CALIFORNIA CLARKSDALE, MISSISSIPPI • BELLEVILLE, ONTARIO

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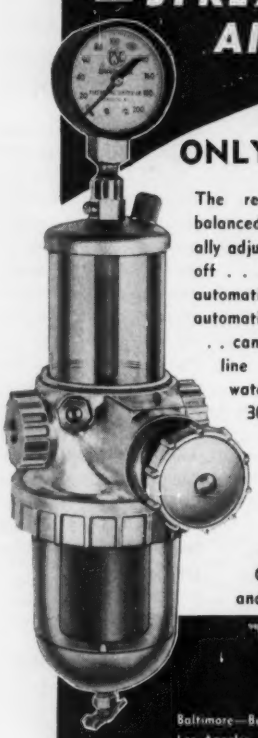
STREAMLINED AIR CONTROL



ONLY 2 Settings Connections

The rest is automatic. Self-cleaning balanced piston REGULATOR automatically adjusts when tools are added or taken off . . . acts as a shut-off valve . . . automatically bleeds off. LUBRICATOR automatically proportions oil to air volume . . can be filled without turning off air line . . . FILTER removes free oil, water, and solid particles down to 30 microns . . . drain valve blow off . . . Filter and Lubricator have visual controls.

To get simplified and positive protection for tools, instruments, etc., standardize on PSC Air Controls. Stocked in ¼", ⅜", ½", and ¾" NPT. Write for Bulletin 80.

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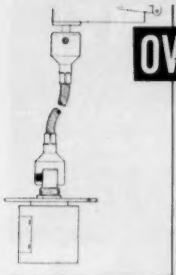
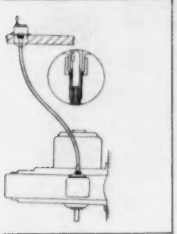
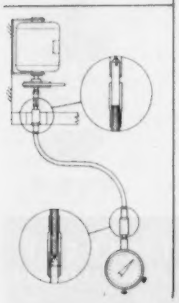
Circle 600 on Page 19



OVER 180 COMBINATIONS





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They are composed of stock components, the finest steel cable, vinyl covered steel casing and cadmium plated coupling type steel and fittings.

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Circle 605 on Page 19

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This free manual shows all sizes and styles of loop clamps, bonding clamps, multiple clamps, center clamps, wire harness clamps, wave-guide clamps—plus blocks, brackets, busbars, line supports, and related items.

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160

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ARROW *Gear Company*

2301 Curtis Street • Downers Grove, Illinois

Circle 607 on Page 19

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before you buy bearings!

in the central states

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Central Regional Office
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HE'LL TELL YOU what our 150-page manual can't. An Instrument Ball Bearing Engineer, he's ready to help you design around standard types and sizes to speed your new developments and cut your costs. He can also consult on the design of special bearings.

HE'LL BE GLAD to send you our manual if you don't already own it. It's now in the hands of more than 50,000 qualified engineers, draftsmen and purchasing agents. Want one?

NEW HAMPSHIRE BALL BEARINGS, INC.
PETERBOROUGH, N. H.

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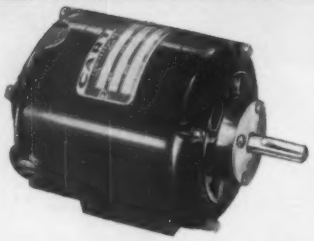
WANT BETTER MOTORS FOR YOUR PRODUCTS?

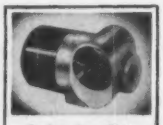


20 STANDARD SHUNT AND SERIES MODELS

1/35 to 1/10 hp.

Then switch to Carter Classic

Interchangeable with competitive types. Exclusive performance features include longer brush life, instrument quality ball bearings in steel sleeved housings, highest quality die-cast construction.



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6 to 220v. Series Models . .
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WRITE for prices, specifications, OEM discounts.

Use letterhead for special attention.

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Large Enough to Serve You, Small Enough to Want to

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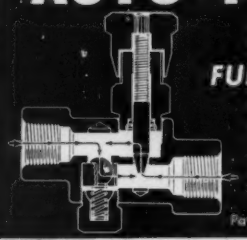

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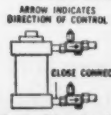

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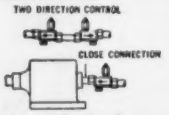

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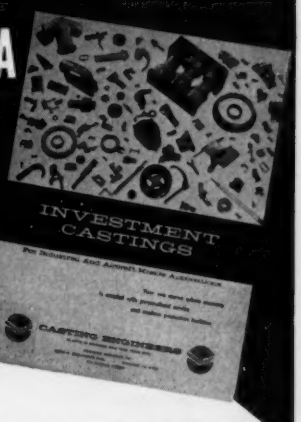

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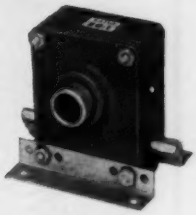

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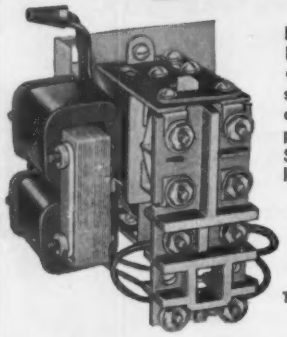

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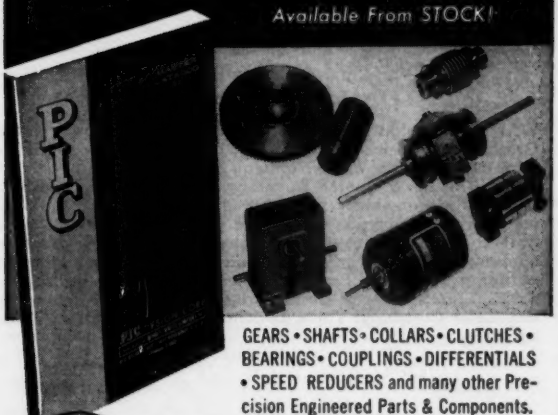

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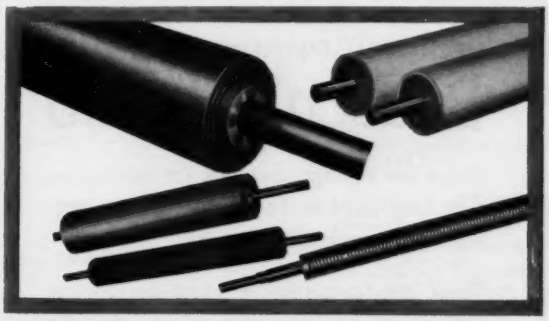

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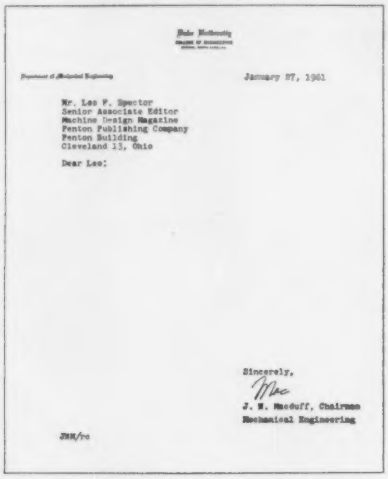
BPA NBP

backtalk——

—Silent Letter

Probably everybody has been on one end or the other of a long, windy letter that really didn't say anything. Antithetic to this type of correspondence, the letter (?) below arrived



Yale University
Department of Mechanical Engineering

January 27, 1961

Mr. Leo F. Spector
Senior Associate Editor
Machine Design Magazine
Penton Publishing Company
Penton Building
Cleveland 13, Ohio

Dear Leo:

Sincerely,

J. N. Macduff, Chairman
Mechanical Engineering

JNM/ro

in Leo Spector's mail recently. Although it *really* says nothing, he got the message at once.

Professor Macduff and Leo have been corresponding during the past months; they both knew that it had been Leo's turn to write for some time, so the professor sent this ever-so-subtle reminder. It was an immediate success.

This story proves at least two things: 1. Editors are human enough to commit the error of procrastination. 2. A really clever and resourceful Scotsman can even be thrifty with words.

—JAM re: FAT on AIM at NWIRP

Since the beginning of wheel-making, every occupation has employed—and enjoyed—its own special jargon. One of the newest businesses, Polaris production, is no exception. Engineers, scientists, and technicians working on the missile at Lockheed's Missiles and Space Div. talk and write Polarisese: Words which are contractions or initial letters of words in long phrases. For instance:

SPALT—Special Projects Alteration
JAM—Job Assignment Memo
PERT—Program Evaluation and Review Technique
FAT—Factory Acceptance Tests
AIM—Active Inert Missile
REB—Re-entry Body Building
MAB—Missile Assembly Building
NWIRP—Naval Weapons Industrial Reserve Plant at Lockheed, Sunnyvale

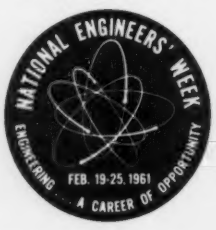
The Lockheeders admit that certain combinations of the words lend a Lewis Carroll touch to their communications, but maintain that they help in the highly accelerated Polaris program.

—The First One Hasn't a Chance

It had to happen: The here-again, gone-again engineer shortage has created a shortage of recruiters of engineers. To fight this, one company reportedly dresses one of its recruiters in sheep's clothing and sends him out to inquire about jobs elsewhere; he then tries to hire the recruiters who talk to him.

—Happy NEW to You

Next week we observe, or celebrate, National Engineers' Week, which is sponsored by the National Society of Professional Engineers each year during the week that two famous members of the profession (George Washington and our Editor, Colin Carmichael) were born.



The week is devoted to publicizing the work of engineers and engineering as a career opportunity for young people. For the latter effort, NSPE makes available—at nominal cost—films, TV slides, newspaper stories, and all manner of posters, buttons, stickers, and seals.

As suggested at the beginning, one can either celebrate NEW or observe it. To celebrate, we can admire the profession and maybe even salute it with a bit of elbow-bending; or we can observe the spirit of the week by trying some twig-bending among the potential engineers we know.

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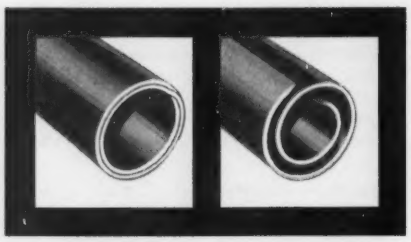

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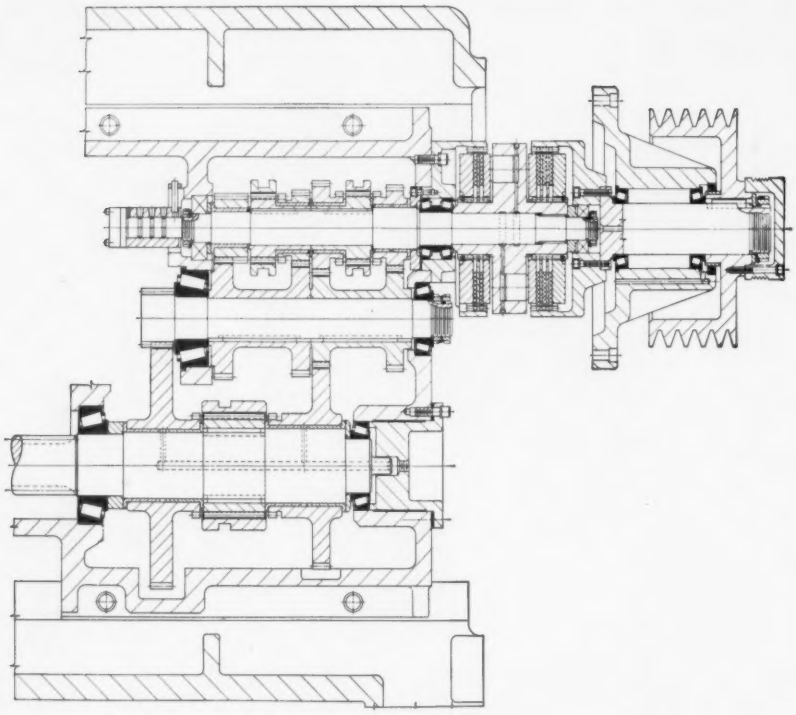

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